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CHILDREN AND THE CINEMA

TOWARDS the close of 1947 the Ministry of Education, the Home Office and the Scottish Office appointed a departmental committee under the chairmanship of Prof. K. C. Wheare to inquire into the effects of attendance at the cinema on children less than sixteen years of age. The report of its findings has now been published*. The Committee has not only interviewed witnesses, visited cinemas and studied memoranda from interested authorities, but has also carried out a number of supplementary investigations of its own. More particularly, in view of the widespread notion that the films are largely responsible for the increase in juvenile delinquency, it has addressed inquiries to chief constables, magistrates, psychologists at child-guidance clinics, and others, asking for opinions based on first-hand experience, and for specific instances (if any) supporting such views. In addition, it has conducted a small research on three hundred boys and girls in approved schools, and on members of children's clubs, in the hope of securing evidence from the children themselves. At the same time, and partly to assist the Committee's deliberations, the Social Survey of the Central Office of Information has undertaken three investigations along scientific lines, using appropriate sampling procedures, with the view of ascertaining the facts as regards the film-going habits of the general public and of the child population†.

The Committee finds no evidence for fastening on the cinema any primary share of responsibility for delinquency and crime. Save for exceptional cases, it believes the physical effects to be insignificant. The nervous effects it considers deplorable; and the general moral effects—the influence exercised on manners, moral values and standards of behaviour—to be subtle and far-reaching. It concludes that the cinema has "great power both for good and for evil".

As a result, the report recommends that "there should be clear and definite statutory provisions, requiring regulations to be made to prescribe minimum standards which must be observed to safeguard the welfare of children attending the cinema". It believes the existing method of classifying films to be unsatisfactory, and proposes an alternative procedure of its own. The task of classification should, it contends, be regarded as essentially different from that of censorship, and be carried out with the assistance of persons who are experts in child psychology. With this and other problems in mind, it is proposed that a central committee on children and the cinema should be set up forthwith by those government departments now concerned with cinema questions; the new body, it is stated, should include persons interested in child welfare, and particularly those who have made a scientific study of the psychology of children. Finally, the report strongly recommends that "scientific investigation should be

* Report of the Departmental Committee on Children and the Cinema. (London: H.M. Stationery Office, 1950.) 3s. net.

† Kathleen Box, "The Cinema and the Public" (1946); Joyce Ward, "Children out of School" (1948), and "Children and the Cinema" (1949), *The Social Survey*, N.S. Nos. 106, 110, 131 (1949).

undertaken as soon as possible into the effects of the cinema on children".

An appendix is added to the report, setting forth a list of those problems which call most urgently for scientific study, and discussing the scientific procedures available for such researches. Among the problems enumerated, the report puts first and foremost those questions which it describes as largely physiological. What, for example, are the effects of the conditions of seating, temperature, ventilation, and the like, on the health and comfort of the children? How far does attendance induce fatigue and eye-strain among children of different ages? What part is played by differences between the brightness of the screen and that of the surrounding surfaces within the field of vision, and by the degree of illumination of the cinema as a whole? What are the effects of the inevitable distortion in shape and apparent movement when the film is viewed from an oblique angle? Although these problems are described in the report as essentially physiological, it ought perhaps to be borne in mind that advances in the study of visual perception have already shown that the psychological aspects of such problems are equally important, and that the views of physiologists and medical experts with no psychological training may therefore be gravely at fault. Secondly, the report enumerates a number of questions which it regards as more definitely psychological. These relate chiefly to the interpretation by the cinema-goer of what he sees upon the screen. At what age, for example, does the normal child begin to take in a story presented on the cinema screen, and when does he first acquire an interest in dialogue? How far is he able to link together successive events and scenes in terms of cause and effect? What features make some pictures seem more real than others to children of various ages? One further topic mentioned in the body of the report might well be added to the list of researches set out in its appendix, namely, the possibility of teaching appreciation of films along the same lines as the appreciation of music, painting and industrial arts.

A third group of problems is described as social; they relate chiefly to the cumulative effects of visits to the cinema on behaviour outside. Here the report considers the available evidence to be seriously defective. If such questions are to be made the subject of scientific research, then, it is rightly urged, special precautions and special technical devices must be employed. "Almost all the prevailing methods in this field," it is said, "rest upon assumptions which stand in need of further and more rigorous testing; what is called the social survey can by itself rarely if ever reach a stage of settled conclusions able to satisfy exact scientific demands." The procedures commonly employed, we are told, "were invented for adult populations, and most of them in America"; and the statistical procedures adopted for analysing the data thus obtained have "almost always been taken over without criticism from those that have proved successful in widely different fields".

Much of this criticism is no doubt fully justified, though it somewhat undermines the value of the evidence on which the Committee has based its own conclusions. It will, too, be generally agreed that a good deal of the earlier American publications dealing with such problems possess little scientific merit. In Great Britain, however, psychologists and educationists have been less inclined to trust exclusively to these more general procedures, and have always insisted that the statistical data obtained on an extensive scale by the cruder devices of the survey should be supplemented by intensive investigations of the case-study type. This has been especially so in the field to which the report has devoted closest attention, namely, that of juvenile delinquency. Here perhaps the Committee may have been a little handicapped by the fact that no leading educational psychologist, familiar with work already carried out, was included among its members.

Nevertheless, the Committee's final statement on the matter is undoubtedly sound. Although, we are told, further experimental studies of a laboratory type are urgently needed, "it cannot be too strongly emphasized that the world of films is a world of its own, whose problems cannot be studied in the laboratory alone". On the Continent, a systematic attempt has already been made to draw up, on an international basis, a list of the more important psychological and social problems raised by the rapid development of the cinema, and to suggest suitable techniques*. It is to be hoped, therefore, that the Committee's appeal for inquiries of a more rigorously scientific character will encourage teams of suitably trained investigators—physicists, physiologists, psychologists, educationists and sociologists—to co-operate in this important field of social research.

* Cf. the recent report of *La Revue internationale de filmologie*, (V), **2**, 1–20 (1949).

ANAXAGORAS: PHILOSOPHER AND ARTIST

The Philosophy of Anaxagoras

An Attempt at Reconstruction. By Felix M. Cleve. Pp. xxiv+167. (New York: King's Crown Press; London: Oxford University Press, 1949.) 16*s.* net.

THE author of this book undertook, in a first "rudimentary attempt", to reconstruct as long ago as 1917 the philosophical system contained in the extant writings of Anaxagoras. Now we have the benefit of a further thirty years of study, and the scholarly treatise here before us is the result. Assuredly, the background cannot have been encouraging; to more than one authority the task appeared meaningless. Moreover, early Greek thought is often regarded as merely fanciful. But we need not agree with these views; they are not sacrosanct, and Dr. F. M. Cleve will have none of them. Even if he emerged from the fray as nothing more than an impenitent rebel, he would have earned our respect; as it is, he returns bearing his sheaves with him—a not inconsiderable harvest.

Superficially, all this is somewhat peculiar. Below the surface, however, we may discern what has happened. The main purpose is to bring about a philosophical reconstruction rather than a philological one. In view of what remains of the master's writings,

the latter enterprise could have had little chance of success; but so long as strict consistency obtains, the former is by no means hopeless. Yet the proposal to set out on the philosopher's way has brought into active commission more wet blankets than enough. In addition, it is very difficult to accept much of the Aristotelian comment and interpretation as trustworthy. Thus, at least one of the natural stepping-stones to a just assessment of the place in history of the wise man of Clazomenæ is decidedly slippery. Why exactly this should be so is not easy to see—the personal equation apparently was never without influence; and when the universal prestige of the Stagirite is added, the verdict is heavily weighted.

Anaxagoras has usually been understood to assume an infinite number of elements. In fact, he states as his opinion only that they are "numerous and diverse". Even so, this is a notable breakaway from the old Ionian tradition; yet the crux of the matter is the exact sense of the words, "seeds infinite in quantity". This phrase might refer to the number of the kinds of seeds, or to the number of the particles making up the various kinds. (How much clearer this idea might have become, had its originator lived to see the discovery of the algebra of classes, or the notion of a 'set'.) Nevertheless, for all his types of seeds, and how many there are, one thing is needful, namely, that not the slightest likeness must exist between them in any particular. This outlaws the atoms of Leucippus and Democritus—with their differences on geometry and velocity only—once and for all.

In the light of these tenets, the broad sweep of the Anaxagorean cosmogony begins to take shape, or rather, the associated world-making (κοσμοποιία). The first and second means are those of differentiation and rotation respectively, followed by both acting together. The third means involves dismemberment of the axis, and is by far the most obscure to modern minds. Dr. Cleve is at his best here, as he strives to disentangle it. Before we tackle this, however, it is well to recollect the unique position assigned to 'nous' (intellect or mind) in the present context. 'He' is not mixed with any element—he sits in sovereign-like detachment; he can do what he likes, because he knows exactly what he can do.

Thus, in starting with differentiation, 'nous' must upset the all-pervading balance or homogeneity of things, in order to produce the world's infinite variety as we know it. The process must begin at one point, or otherwise a species of statistical jumble would come about, inimical to world structure. In this is manifest a very primitive suggestion of entropy, as well as the implication that, had differentiation 'flared up' all over the place, nothing but a kind of gas kinetics would have arisen, with zero resultant.

So far, so good. The omniscient physicist–engineer–architect could not be satisfied with this order of Nature, however, for it offered by itself merely a stratified globe of increasing size. 'Nous' knew what to do next; he would introduce a 'going round about', with its 'quickness that produces force'. Rotation has arrived, and something uncommonly like angular-velocity. This is remarkable enough, but the motive is more intriguing still. It is unmistakably æsthetic. The master-builder's sense of fitness, appropriateness and function was outraged by the monotony of differentiation into strata; something altogether more lovely and satisfying was imperative. Hence, translation must be reinforced by rotation. The law of *prägnanz*, beloved of *gestalt*-psychologists these past few decades, to make the world safe for stationary states of minimal energy (including æsthetic), seems to have occurred to Anaxagoras almost overnight.

The moon caused him grave anxiety, especially in connexion with his plan for differentiation and rotation working together. Thales had established that moonlight was but reflected sunlight, but each heavenly body was, for Anaxagoras, a lump of glowing stone or μύδρος. It was hard to exempt the moon from this astrophysical generalization; yet it had to be done somehow, and its relative nearness to the earth, compared with the sun, did not help matters. So Anaxagoras retained the μύδρος character, but declared the lunar composition to be irregular, having hollows mixed with the cold. This incursion into metaphysics may offend us to-day: it was but a temporary expedient, honest and resolute. Many a natural philosopher has taken similar refuge in a storm.

With his theory of invisible celestial objects, the strong æsthetic sense in Anaxagoras bursts out anew. If symmetry demands entities invisible to us, it is legitimate to postulate their existence. There speaks the true artist.

But much of this, we gather, seemed trivial compared with the vast problem presented by day and night. So far, 'nous' had not provided for sunrise or sunset (or, for that matter, the corresponding effect for all the contents of the heavens). The identity of all the axes of rotation—accepted so far—must be abolished, the common axis dismembered. Without following the details of this severe operation, we can admire once again the intellectual fortitude of the master in facing the facts. This must, indeed, have occasioned a distressing "pain in the mind", particularly as all doctrines subversive of "authority" were dangerous to those who professed them.

Thus far, we have concentrated upon Anaxagoras the master-builder and natural philosopher. His distinguished place for all time must be mainly due to his efforts in those capacities. Yet, this amazing personality presents us with constructive comments in biology and psychology as well. An example is the remark, concerning the difference to be observed in relative intelligence between created things, that it is due to his having hands that man is the most intelligent animal. As Dr. Cleve points out, it is most odd that Aristotle of all people should have objected to this statement, even wishing in effect to reverse it.

These erudite pages end with a register of authorities. It is a formidable list; but the inclusion of a reference to Prof. K. O. Müller's interesting brief discussion of the Anaximander–Heraclitus–Anaxagoras 'triangle' ("Literature of Ancient Greece", 1; 1858) would have strengthened it still further.

Dr. Cleve has contributed something intrinsically more valuable and illuminating (in spite of one or two points upon which agreement is not assured) than anything that has appeared in recent years on the subject of Anaxagoras of Clazomenæ, with the sole exception perhaps of the late Prof. A. E. Taylor's "The Date of the Trial of Anaxagoras" (1917). In any event, what matters is to bring to light and examination every particle of knowledge which research can unravel concerning men of genius like this. As Prof. J. E. Littlewood once put it, "They are not clever schoolboys or scholarship candidates, but Fellows of another College".

F. I. G. Rawlins

AMID THE HIGH CAIRNGORMS

The Cairngorms on Foot and Ski
By V. A. Firsoff. Pp. 279+49 plates. (London: Robert Hale, Ltd., 1949.) 15*s*. net.

THE range of the Cairngorms is in the opinion of many people the finest mountain land in Britain. Mr. V. A. Firsoff in this book has written of his experiences of this hill range. He describes how he saw them first during the grim years of the Second World War, and since that day he has climbed and photographed them not only in summer, but also in winter when, like the Norwegian troops stationed in the district during the War, he has roamed their high plateaux on skis in all weathers, sometimes battling with blizzards so fierce that life itself seems precarious. The illustrations which he has taken with his camera show that he has an eye to a good picture; some of them are excellent. He writes clearly and graphically, and we follow him on his climbs from the Linn of Dee and from Achlean in Glen Feshie, from which hospitable house he first made the acquaintance of the Cairngorms in the war years.

Mr. Firsoff has a good deal to say about the ancient forests of Scots fir and their ruthless felling, not only during the War but also afterwards. I am glad that he directs attention to the danger that we may lose entirely these fine woods. This can be prevented, on the south slopes of the Cairngorms at all events, by fencing in areas against deer and allowing the seedlings to make a start. I have repeatedly urged this, yet nothing has been done; as it is, each seedling is eaten, and in Mar Forest there is not a single young tree to be seen. Mr. Firsoff writes of the recently formed National Park in Glen More, and the possibility of the whole range becoming a larger national park.

In his botanical chapter the author makes some surprising statements, as, for example, when (p. 46) he writes: "In Coire Beanaidh along the scarp of Sron na Lairig I came across carpets of purple saxifrage in livid bud, on the point of opening". I have known the Cairngorms for the best part of forty-five years but have yet to find, nor do I know any botanist who has found, this schist-loving saxifrage on the high tops or in the high corries of the Cairngorms, where the granite formation is distasteful to it. Nor (p. 48) have I found the blaeberry (*Vaccinium myrtillus*) abundant at the Wells of Dee where I have spent, at one time or another, a considerable number of days. The mossy cyphel has not been recorded from the Cairngorm area and not nearer than seventy miles from it. *Azalea procumbens* flowers earlier, and not later, than *Silene acaulis*, unless it has been kept back, as it sometimes is, by extensive snow fields remaining until late spring on its flowering slopes.

I am perplexed, too, by the author's Camberwell Beauty butterfly (p. 19), which he saw in winter in Glen Feshie. This butterfly is a rare vagrant and is seen mostly on the east coast. To have seen it in February in Glen Feshie surely merits more than a passing casual remark. There was never (p. 74) a colony of black-headed gulls on Loch nan Stuirteag.

On p. 88 he talks of seeing the Cuillin Hills of Skye from the Cairngorms, but he has confused them with the Sisters of Kintail. There is, it is true, a tradition in Rothiemurchus that the Cuillin are visible, but the shape of those distant pointed hills is not the shape of the Cuillin. I consulted the Ordnance Survey on this question, and they were good enough to interest themselves in the matter and informed me that, because of an intervening hill sixty miles distant, the Cuillin are invisible from the Cairngorms.

The book is excellently produced. In a second edition, which is sure to follow, the errors Uisga for Uisge (p. 14), statistickal for statistical on p. 36, and on p. 30 the English translation of Moine Bhealaidh will doubtless be rectified. SETON GORDON

IN PRAISE OF EPPING FOREST

London's Epping Forest
By James A. Brimble. Pp. 176. (London: Country Life, Ltd., 1950.) 30*s*. net.

WHEN you pick up this handsome book, you find yourself either immediately interested in Epping Forest ("It is little more than half an hour from Town. . . . And oh! so near to London!") or fascinated by the superb photographs.

Epping Forest is a comparatively large natural area stretching from the north-eastern edge of urban Greater London deep into the heart of rural, agricultural Essex. Part is actual forest; but other parts are suburban in character and there are some small areas of common, copse and verge. (Mr. Brimble deals only with a section of the forest.) It is a forest with a history, too. One needs only to mention such as the ancient British camps of Ambersbury Banks and Loughton, Waltham Abbey and Hainault to remind the reader that here was where much of Britain's history was enacted. Also as a forest, this area has for centuries played an important part. The Normans used the area for hunting. Deforestation occurred under the weak regimes of John and Edward I; but afforestation was the order of the day under nearly all the Henries. Then the area was the scene of many a royal hunt—the Norman kings, the Plantagenets, the Tudors and the Stuarts—reaching its peak with Henry VIII; but the hunts ceased after Charles II. The forestry programme of the area has suffered many vicissitudes, and even Parliament has not been guiltless of making easy money from the sale of timber that this area afforded; that is how the part known as Hainault Forest disappeared so recently as 1851. Finally in 1878, by an Act of Parliament, six thousand acres, now called Epping Forest, were placed under the administration of the Corporation of the City of London. Such is the position to-day.

We are told this, and much more besides, by the author, who then proceeds, in fifteen engaging chapters, to describe the Forest of to-day.

There is animal life, too. Domesticated cattle and horses from adjoining farms graze on the lawns (or Forest plains as they are called); the well-known deer number about two thousand. Some foxes are allowed, and almost invariably badgers eventually take over the formers' earths and enlarge them for themselves. Also, alas, the immigrant grey squirrel is now becoming a pest there.

The text abounds with descriptions which will appeal to all natural historians, for it is written by a man who has spent twenty-five years of his life on the edge of the Forest.

The most outstanding feature of the book, nevertheless, are the 115 photographs, all of which have been taken by the author. He is well known as a

photographer of country-life, especially tree studies, and here he regales us with some of the best examples of his art. No lover of Nature, no amateur or professional photographer, could fail to be charmed by these studies of country-life taken in all moods and in every season, and through the medium of these photographs the book must appeal to many more than those who merely want to know about Epping Forest. Notwithstanding this, Londoners and others who contemplate visiting that area would do well to consult this book first.

Mr. Brimble (no relative of one of *Nature's* editors of the same name) is a book-seller, and the present volume is the fruit of his well-spent leisure. Both he and his publishers are to be congratulated on a well-written, superbly illustrated and handsomely produced book.

PRACTICAL PHYSICAL CHEMISTRY

Physico-Chemical Methods

By Prof. Joseph Reilly and Prof. William Norman Rae. Vol. 3 (Supplementary). Pp. ix+698. (London: Methuen and Co., Ltd., 1948.) 55*s*. net.

THIS book is a supplementary volume to the fourth revised edition of "Reilly and Rae" published in 1943. It contains much material that could not be accommodated in Vols. 1 and 2 and much additional information that has become available as a result of post-war advances in physical chemistry. It may truthfully be said there is no defined limit to physico-chemical methods. On one hand, much that the physicist has developed in other connexions is rapidly adapted and modified for purely chemical purposes; on the other hand, the application of physical chemistry to substances and reactions of biological interest has pushed forward to the extreme the developments of highly complex physical chemical methods. Due regard is paid in this volume to these important borderline activities in modern physical chemistry. From this it becomes evident that no pair of authors can possibly have even a nodding acquaintance with the limitless variety of topics that must find a place in a comprehensive reference book of this kind. A number of chapters are therefore written by other authors who have a special knowledge of the subjects discussed.

The selection and balance of the topics is a most difficult one, and no two physical chemists would agree on this point. The book opens with a brief account of electron optics as a preliminary to a description of the electron microscope. Few physical chemists would now try to build such a highly specialized instrument; it is therefore a pertinent question as to whether valuable space in this book should properly be devoted to this subject. Similar remarks might be made of the chapter on the mass spectrograph, except that here an indication of its usefulness rather than its construction should now find a place in any physical text-book of an advanced character. The chapter on photo-physics—mainly on photocells—is extremely useful and could be expanded with advantage in a future edition, for chemists are not always aware of what can be done with these tools. The determination of atomic and molecular weights occupies a considerable portion, due emphasis being paid to micro methods for molecular weight determination. Osmotic pressure apparatus is adequately dealt with, and more information about modern instruments for measuring very small pressures would be welcome. The procedure, rather than the apparatus, for dealing with homogeneous reaction velocities is set out in detail so that effective use may be made of the more practical procedures described in other parts of the volumes. Chromatography properly gets its due quota of space, and the theory is properly considered so that the approach to it need not be purely empirical. The preparation of colloidal solutions perhaps occupies a rather large amount of space, since the quantitative significance of the subject is never particularly high. There are many more topics, but lack of space prevents their being mentioned.

The great value of a work of this kind is as a source book for guidance—it cannot be critical, for the subject is too vast. What it can and does do is to provide the reader with ideas, methods of approach and devices to help him in his particular problems in this field of chemistry. H. W. MELVILLE

GENERAL INTRODUCTION TO ADVANCED MAGNETISM

Magnetism

By Dr. David Shoenberg. (Sigma Introductions to Science, 12.) Pp. x+216+8 plates. (London: Sigma Books, Ltd., 1949.) 10*s*. 6*d*. net.

TO give a satisfying account of magnetism in some two hundred pages is a considerable undertaking; to accomplish this as excellently as he has done, Dr. Shoenberg must have given a great deal of thought to the impact of quantitative ideas and conventions on the general reader meeting them for the first time. In the early chapters, the single magnetic pole is soon discarded for the dipole, and the relation between magnetism, electricity and atomic structure is pursued via magnetic shells to electron orbits and the ultimate spin. None of the essential theory of elementary magnetism is omitted, but it appears in a guise less formidable and more convincing than usual.

The account of magnetic materials and ferromagnetics is valuable from two points of view: the domain-structure idea and some evidence for it are well explained; and there is also some quantitative discussion of such points as the importance of coercivity rather than merely remanence for a permanent-magnet steel, and what happens when a keeper is removed and replaced again. There are chapters on terrestrial magnetism, the use of magnetism as a tool in scientific work, and some everyday applications of it. These are not very detailed, but the book is professedly an introduction and lives up to this by giving a list of standard works in which the topics may be pursued further. The glossary-index combination is a useful idea. The diagrams are good, but the eight plates would have brightened the volume more if they had been spaced out instead of being centralized.

The author is lecturer in physics in the University of Cambridge and head of the Royal Society Mond Laboratory at Cambridge, having been there since 1932. As the publishers state, the book is of a more advanced character than most of the Sigma series, and it should be useful to the serious student as well as to the general reader, both of whom will appreciate in its pages the authentic hand of the expert.

G. R. NOAKES

Umbundu Kinship and Character

Being a Description of the Social Structure and Individual Development of the Ovimbundu of Angola, with Observations concerning the Bearing on the Enterprise of Christian Missions of certain Phases of the Life and Culture Described. By Gladwyn Murray Childs. (Published for the International African Institute and the Witwatersrand University Press.) Pp. xviii+246+16 plates. (London, New York and Toronto: Oxford University Press, 1949.) 21*s.* net.

THIS is a useful study of the Mbundu, alias Ovimbundu, the largest and most vigorous tribal group in the Portuguese colony of Angola. The manuscript was completed ten years ago, and it is a pity that it could not have been published before, as it helps to fill a serious gap in our knowledge of this part of south-western Africa. It will be of considerable value not only to missionaries and those concerned with the government of this territory, but also to anthropologists, particularly those concerned with the study of social organisation and of social psychology.

The book contains three sections: the first dealing with the kinship structure and the bilateral aspects of Mbundu lineages; the second with the mental development and education of the individual in Mbundu society; and the third with Mbundu history. Those interested in the comparative study of southern Bantu peoples will find these studies extremely useful, but will probably share the reviewer's regret that the author has tried to compress into a book of 220-odd pages material that could well have gone into three volumes. As a result, certain sections of the book, particularly those dealing with kinship organisation, are obscure and lacking in explanatory details.

The editing is of the usual high standard set by publications of the International African Institute, although one wonders why the editor should want to increase publication costs by including plates of wounded bull elands, decapitated wart hogs and similar subjects having no relation to the text.

The Yeast Cell

Its Genetics and Cytology. By Carl C. Lindgren. Pp. xviii+358+7. (Saint Louis: Educational Publishers, Inc., 1949.) n.p.

THERE are many forms of life, once thought to be unusual, or even unique in their structure and functions, which have afterwards proved to be more orthodox than they were believed to be. So, in the case of yeasts, this book shows them to be conventional cells, possessing chromosomes, centrosomes and mitochondria, and behaving cytologically and genetically like any other cell. There are, indeed, aspects of the genetical behaviour of yeasts, especially the apparently irregular segregation of allelomorphs in certain cases, which may appear to support the heterodoxy which is sometimes claimed for them; but even in these cases, the author has abandoned the hypothesis of the maintenance, under the influence of a specific substrate, of a fermentative character for which no gene is present. He has also brought experimental evidence to reinforce the classical view of the importance of the chromosome, while revising and developing the concept of the physical nature of the gene.

The majority of the material is derived from the researches of the author and his associates, and the book is accordingly very profusely illustrated by plates, diagrams and tables. These suffer considerably from the off-set printing technique which, together with the unusual method of numbering the pages by chapters, gives the entire book an unfamiliar appearance. A more serious defect is the absence of an index, which is difficult to forgive in a work of this nature.

In view of the great and growing debt of enzyme chemistry and of genetics to the study of the yeast cell, the value of the book is unquestionable, and the field which it covers is wider than the subtitle suggests.

K. A. BISSET

The Living Soil

Evidence of the Importance to Human Health of Soil Vitality, with Special Reference to National Planning. By E. B. Balfour. Revised edition. Pp. 270+14 plates. (London: Faber and Faber, Ltd., 1949.) 15*s.* net.

THIS beautifully produced book diligently presents the faith of a sect which holds that 'vitality' of soil is important for human health. Incorruptibility can be approached through use of compost and organic manures on terms which the book sets out.

The exposition is sincere, but will have little interest to the man of science unless he be a sociologist. It would be a mistake to judge by orthodox scientific standards the tenets of this biologically based cult which freely uses the terminology of science but rejects its methodology, which confuses testimony with evidence and has a primitive approach to experimentation. The pseudo-scientific approach is exemplified by reliance on vitamin B as understood *c.* 1929. The book may be useful for its information about the Soil Association and the composition and aims of the Haughley Research Trust which was established to put compost-farming to the proof. It reveals a tangled, kindly web of thought, which deceives nobody except its spinners and voluntary adherents in search of comfort for their souls. Such people are more numerous than men of science; and it would be surprising if the book were not a success.

HUGH NICOL

Fish and Fish Inspection

By John D. Syme. Pp. viii+162. (London: H. K. Lewis and Co., Ltd., 1949.) 18*s.* net.

THIS book has been written primarily for the use of food inspectors and students preparing for the certificate of the Royal Sanitary Institute. It begins with brief descriptions of modern fishing-vessels and gear, and of the various fishing-grounds on which they work. Then follows an important chapter on how to identify the various species of fish commonly met with in British fish-markets and on fishmongers' slabs. The descriptions are expressed in plain language and each is accompanied by a black-and-white drawing of the species mentioned. The exclusion of all scientific terms from the descriptions is probably an advantage for non-specialists, but even they would certainly have benefited if at least the scientific names had been given in addition to the common names by which the different kinds are known to the trade.

Chapters on fish inspection, preparation and transport, and the various methods of fish processing appear to be adequate for the purpose. The book is well produced in an attractive format and should have a ready sale in trade circles.

G. A. STEVEN

FAMOUS EXPERIMENTAL APPARATUS IN THE CAVENDISH LABORATORY, CAMBRIDGE*

By Sir LAWRENCE BRAGG, O.B.E., F.R.S.

THERE exists in the Cavendish Laboratory an extensive collection of apparatus used in the great era of classical physics. The start of modern physics is generally identified with J. J. Thomson's experiments on the electron in 1896, but a revolution of equal importance was taking place in the times of Maxwell and Rayleigh, the first two holders of the Cavendish chair. Physics was becoming established as an experimental science with a field of its own apart from those hitherto embraced in natural philosophy and chemistry, and for the first time a home was being officially provided for it by the University, where students could do experiments and the staff could pursue research.

It is rather startling to realize at what a late date the idea of an experimental laboratory took shape. The earliest record of anything of the kind appears to be the laboratory in a wine-cellar in one of the professors' houses at Glasgow, which Kelvin fitted up in 1846. Clifton started a laboratory in a room at Oxford in 1868, and the Clarendon Laboratory was completed in 1872. Tradition has it, however, that this famous building was more used for demonstrations to students than experiments which they were allowed to perform themselves. Cambridge followed with the building of the Cavendish Laboratory, begun in 1871 and completed in 1874. Until that time the tradition throughout British universities had been that while the professor gave his lectures in natural philosophy in university lecture rooms, research was his private concern, to be carried out where he could. Just as Newton experimented in his rooms in Trinity Great Court, Cambridge, so Maxwell while at King's College, London, made some of his most famous experimental researches in a garret at 8 Palace Gardens, where he lived. When Maxwell was appointed to the chair at Cambridge in 1871, he planned a laboratory with rooms specially designed for experimental work of various kinds. Rayleigh, besides developing the practical classes, added a workshop to the laboratory, and started an apparatus fund. Under them the laboratory began to assume something like its modern form. Maxwell presented all his experimental apparatus to the Cavendish Laboratory, and much of the apparatus with which Rayleigh established the absolute values of the electrical units is also preserved there. It is of great interest to see how these men worked in the days when there were no instrument-makers and no skilled team of mechanics in a laboratory workshop.

Maxwell's earliest experiments were designed to test Young's theory of colour vision, that any colour could be matched by a suitable mixture of three primary colours. While still at Cambridge, before he was appointed to the chair at Marischal College, Aberdeen, in 1856, he made a top on which disks of different colours could be placed, so that when the top was spun these disks blended together. Three large slotted disks of the primary colours red, green and blue could be so adjusted that their areas had any desired ratio, and a smaller disk of the colour to be matched compounded with black or white was placed at the centre of the top. The original is in the Cavendish Laboratory museum, as is also his elaboration of the principle in his colour box. This has several very interesting features. If white light from a slit passes through a prism and forms a spectrum, by selecting certain portions of this spectrum and superimposing them on top of each other one can get a mixture of the three primary colours in any desired proportions. Maxwell very ingeniously reversed the apparatus. At the place where the spectrum is formed Maxwell placed three adjustable slits and illuminated them with white light. The eye replaces the source of light at the slit, and looking into the prism the three colours defined by the slits are seen superimposed to give a composite sensation. This is matched against a standard colour seen alongside it. The slits are connected by a black paper bellows ingeniously constructed so that it can be placed in any suitable position. It is very interesting to note that Maxwell used in his colour box the principle afterwards adopted in the Littrow mounting. The light passes through a train of two prisms, is reflected normally at a concave mirror and retraces its path. Another interesting device is that which Maxwell employed to measure the width of his slits. He had a thin tapered gauge which he rested on his finger and inserted into the slit, pushing it forward until it slid over his finger so that the same pressure was always exerted. The box in the Cavendish Laboratory contains most of the original optical parts; the prisms are badly corroded, but can be made to work by fastening thin plates to their surfaces with Canada balsam. Maxwell worked with this apparatus at 8 Palace Gardens while professor at King's College, London, and gave his first Royal Institution lecture in 1861 on the theory of the three primary sensations of colour.

While at Marischal College, Aberdeen, Maxwell worked on the theory of Saturn's rings. He proved that the rings could not be solid or liquid, but must consist of a number of discrete particles, and he constructed a small brass model to illustrate the perturbations of the satellites in the rings. This model is still in perfect working order. It has been suggested that Maxwell's work on the mutual influence of the components of the rings led him to speculate about the dynamical theory of gases.

Another treasured object in the collection is the apparatus with which Maxwell measured the viscosity of gases. It is recorded that, in order to measure the viscosity at different temperatures, his faithful wife stoked up the room to the requisite temperature by many fires and kettles of water, and that blocks of ice were brought in to cool it down when necessary.

Another very intriguing piece of apparatus is that for comparing the electrostatic and electromagnetic units. A comparison had been made by Weber and Kohlrausch in 1856, who by discharging a condenser through a galvanometer were able to compare its capacity in electrostatic and electromagnetic units.

* From a Friday Evening Discourse at the Royal Institution on May 12.

For his purpose Maxwell borrowed from Gassiot his "magnificent battery of 2,600 cells charged with corrosive sublimate". Maxwell balanced an electrostatic attraction of two parallel plates connected to the poles of this battery against the repulsion of two parallel coils in which a current from the battery passed in series with a large resistance of 1 million ohms. His result for the velocity of light was 288,000,000 metres per second.

Maxwell did little experimental work while professor at the Cavendish. What time he could spare from teaching and from the building and equipping of the new Laboratory, which was only completed in 1877, two years before his death, was mainly devoted to editing Cavendish's experiments on electricity and repeating the more important of them. One experiment carried out in the Cavendish Laboratory was the verification of Ohm's law. This was sponsored by a British Association committee, and the account of it appears in the British Association Report for 1876. It is rather striking to see how much scientific work was sponsored by committees in those days; some seventeen committee reports appear in the British Association journal for 1876, on such diverse subjects as the practicability of adopting a common measure of value in the assessment of taxation, the steering qualities of ships, and the suggestion of suitable research experiments to be carried out in chemical laboratories.

Maxwell's method for the verification of Ohm's law was to compare a long thick wire A with a short thin one B of similar resistance in a Wheatstone bridge, first obtaining a balance with a weak current and then testing whether the balance remained good for a strong one. The current density in the long thick wire was, of course, much less than in the short thin one, and any diversion from Ohm's law would be shown by the balance altering when the strength of the current was altered. The difficulty in the straightforward experiment was that the shorter wire heated with the current. It was necessary to alternate rapidly between strong and weak currents, so that the temperature of the wires should remain steady. A balance did not by itself prove the point, because there might on the average be a balance, although the resistance A was greater than B for a strong current and less than B for a weak one. If, however, the balance still held good when the weak current through B was passed in the reverse direction to the strong current through A, Ohm's law must be true. Maxwell proved that it was correct to one part in 10^{12}. This gave rise to his famous comment, "It is seldom, if ever, that so searching a test has been applied to a law which was originally established by experiment, and which must still be considered a purely empirical law, as it has not hitherto been deduced from the fundamental principles of dynamics. But the mode in which it has borne this test not only warrants our entire reliance on its accuracy within the limit of ordinary experimental work, but encourages us to believe that the simplicity of an empirical law may be an argument for its exactness, even when we are not able to show that the law is a consequence of elementary dynamical principles."

Maxwell also repeated Cavendish's famous experiments to prove the inverse square law. The apparatus consists of two concentric spheres, the inner of which can be connected to or insulated from the outer at will. The outer sphere is charged while connected to the inner, and the connexion is then broken. When the two halves of the outer sphere are removed, the inner sphere is found to be uncharged. Cavendish, with his crude pithball electroscope, showed that the index of the distance was 2 to within 1/50 either way. Maxwell proved that it was correct to 1 part in 20,000.

The apparatus with which Maxwell attempted to discover the mechanical angular momentum associated with magnetization of an iron core was, of course, far too insensitive to detect this very minute effect, but it is very ingeniously constructed. The core was set spinning and could be magnetized or demagnetized at will. A very slight movement of the axis of rotation could have been detected, but none was observed.

When Maxwell was invited to go to Cambridge, he doubted his ability as an experimentalist and his power to design a practical course for a class, and, of course, his fame rests on his very great contributions to theoretical physics. However, the apparatus shows that he was an able experimenter with a real gift for simple design.

Rayleigh succeeded Maxwell in 1879. His practical contributions to the Laboratory were the institution of an apparatus fund, the establishment of a workshop with a mechanic, the reorganisation of the practical teaching under Glazebrook and Shaw as demonstrators (whose book was the basis of practical teaching in so many university laboratories in the early days) and the gift of his Nobel Prize in 1903 with which the Rayleigh Wing was built. While at Cambridge he carried on the stupendous series of original contributions for which he is so famous; sixty in all were published during his Cambridge years, on subjects as diverse as the sensitive flame, capillarity, colours of thin plates, resolving power, acoustics and the balance. As experimental work, he planned a series of investigations to which a team could devote its efforts and selected the establishment of the electrical standards in absolute measure. Rayleigh's work on the British Association unit of resistance, the specific resistance of mercury, the E.M.F. of Clark cells, and the electro-chemical equivalent of silver was the basis of the internationally accepted units for the ohm, ampere and volt.

Brief reference may perhaps be made to one of these determinations, because it had an interesting sequel. With Schuster he repeated the determination of a resistance in absolute units which had been carried out by a British Association committee appointed for that purpose, and corrected its result, which was very considerably in error. The method consists in spinning a coil about a vertical axis with a magnet suspended at its centre. The currents induced in the coil by the earth's field cause the magnet to deviate from the north–south position. Rayleigh drove the coil with a small water impulse engine fed from a tank in the roof of the Laboratory, because he found this to give the most steady result. The speed was measured by attaching a stroboscopic disk to the coil and looking at it through the slits on the prongs of a calibrated tuning fork. The coil was driven by a string belt from the water turbine; and Rayleigh records that he tried various ways of regulating the speed, but found it best in the end while watching the stroboscope to "allow the cord to run lightly through the fingers" and keep a spot on the stroboscopic disk in position by adjusting their pressure. One can picture what a complicated apparatus for control, probably involving many valves, would be set up nowadays. He finally traced the errors of the British Association committee to

two causes: the axial and transverse dimensions of the coil had been transposed in a calculation of the correction for its finite size; and in some mysterious way he discovered, "after much vexation and delay", that the self-induction, which also involved a correction, had been measured on a scale ten times less than its true value. A fascinating result of this experiment on resistance was that it led him to the 'Rayleigh disk' as a method of measuring the strength of a sound. In the first method to determine the speed of rotation, which Rayleigh afterwards improved, a bell rang at the termination of a certain number of revolutions. Rayleigh noticed that the magnet was displaced every time the bell rang and traced this to the action of the sound of the bell on the mirror attached to the magnet. He set up an apparatus to investigate the effect, and this was the origin of the well-known 'Rayleigh disk', a standard way of measuring the intensity of sound.

Finally, there is one other classic piece of apparatus in the Laboratory collection, which might be mentioned because, although the experiment was done at a later date, it is in the classical tradition. This is the magnetic detector which Rutherford brought with him from New Zealand, and with which he sent wireless messages over a distance of about a mile. A fine bundle of steel wires is surrounded by a small coil; a current is passed through this to magnetize the wires, and the coil is then attached to the antenna. When this picks up oscillations from a Hertzian oscillator, the alternating current in the solenoid demagnetizes the steel wires, and this can be detected by a small magnetometer. Rutherford had high hopes of his invention as a money-making proposition, as a letter to his fiancée in 1896 shows. He hoped it might prove to be a means of signalling over ten miles or more to such places as lighthouses. The invention was submitted to Kelvin, who was discouraging about it, and nothing further was done. This was, of course, before the days of Marconi's experiments, and it is interesting to reflect what the history of wireless might have been had Rutherford not been diverted to other lines of research.

THE NEUROGENIC HEART AND ETHER ANÆSTHESIA

By A. E. NEEDHAM

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IT has been shown[1] that the distinction between hearts which are inhibited by acetylcholine, in low concentration (10^{-8}), and those which are accelerated, usually by substantially higher concentrations (10^{-6}), corresponds essentially to the classical distinction between 'myogenic' and 'neurogenic' types[2]. These two contrasted types of heart also differ in ease of tetanization[3], simultaneity or sequence of the contraction throughout the intact heart[4,5], etc. The distinction is also supported by an independent approach, outlined below.

Neurogenic Type of Crustacean Heart

In using ether ($\frac{1}{4}$–$\frac{1}{2}$ saturated aqueous solution) as an anæsthetic for the isopod crustacean *Asellus aquaticus* (neurogenic heart), striking differences have been observed between the sequence of events and those typical of ether anæsthesia in the mammals[6] (myogenic heart), which may well be correlated with their contrasted types of heart. In the mammals, ether anæsthesia affects first the highest centres of the brain, leading to loss of consciousness, on the afferent side, and to failure of spontaneous (that is, 'voluntary') movement on the motor side. Next, the centres of the brain stem—basal ganglia, cerebellum, etc.—are affected in order, from above downwards, and then the spinal centres, probably in the reverse order, from below upwards, leading to failure of spinal reflex activity, and to complete relaxation of the somatic musculature. Halted at this stage the anæsthesia leaves the vital cardio-vascular and respiratory mechanisms little affected, and the value of ether as an anæsthetic for the mammal is naturally dependent on the differential resistance of these mechanisms.

In *Asellus* the same general effects are evident, namely, the initial stimulation of activity, followed by a phase of general muscular spasticity, with ventriflexion of the body, which gives place to a second, feebler burst of activity—becoming local and unco-ordinated—and, finally, to complete relaxation. The essential difference from the sequence of events in a mammal is that the heart and respiratory organs (gills) are typically arrested as soon as, and often appreciably earlier than, somatic movements. There are individual variations in the precise time relations; but in no instance does the heart-beat outlast reflex somatic movements. In spite of the cardiac arrest, however, complete recovery from this stage is usual, and the anæsthetic has proved very satisfactory for this animal. Complete quiescence of the heart for periods up to one hour is not necessarily fatal. Chloroform acts in essentially the same way but is a less satisfactory anæsthetic because of its low volatility.

In recovery the sequence is reversed. The gut musculature is most resistant, and recovers first; next somatic movements recommence, and finally the heart and gills, again with some individual variation in the precise time relations. The recovery of the heart begins as a local twitching of the ostial valves, whence activity sweeps suddenly to the rest of the myocardium.

The demonstration that the heart of *Asellus* is neurogenic on Prosser's criterion has been confirmed on the isolated heart preparation, the effective concentration of acetylcholine for cardio-acceleration being essentially the same (10^{-8}) as for the intact animal[1].

Talorchestia is listed as a neurogenic type[1], and the response to ether of the heart of another amphipod crustacean, *Gammarus pulex*, has therefore been investigated. The response is essentially as in *Asellus*, with two minor differences: (*a*) the general sensitivity of the whole animal is greater, and (*b*) the relative sensitivity of the heart is greater. *Gammarus* therefore exemplifies the neurogenic type even more clearly than *Asellus*, on the present criterion.

If the anæsthetic be discontinued as soon as anæsthesia is complete, recovery in *Gammarus* is more rapid than in *Asellus*. Since the necessary time of exposure is shorter in *Gammarus*, it would seem that the anæsthetic produces other, invisible, effects the extent of which is simply proportional to time of exposure, irrespective of the degree of resistance of the neuromuscular systems (cf. *Diaptomus*, below).

The high resistance to anæsthesia of the vertebrate heart is conceivably a biological adaptation correlated with the absolute indispensability of an incessant circulation. Is an incessant circulation then not vital in animals with a neurogenic heart? *Asellus* and *Gammarus* are possibly sufficiently small (say 10 × 3 × 1 mm.) for oxygen, adequate for the *quiescent* animal, to diffuse through the general body surface, and it would seem more critical to test larger Crustacea with a neurogenic heart. Available records[1,7] indicate that all decapod Crustacea are neurogenic, and the shore-crab, *Carcinus mœnas*, has therefore been used (after cutting a window in the carapace, within the heart-impression, and sealing with celloidin). As in *Asellus* and *Gammarus*, cardiac arrest is induced by ether (vapour, in air) at least as soon as somatic movements. Moreover, recovery is complete from the stage of complete quiescence of heart and limbs. The magnitude of the oxygen debt incurred during anæsthesia constitutes an interesting further problem. The rate of recovery in *Carcinus* is slow (1–2 hr. as contrasted with 2–5 min. for a lightly anæsthetized *Asellus* or *Gammarus*). Whatever the magnitude of the oxygen debt, it is normally not fatal, and the typical, apparently very unadaptive, response of the neurogenic heart to anæsthetics may be regarded as a physiological disability but not as an utter calamity.

The heart of *Carcinus* and of the other neurogenic crustacea does, in fact, show short periods of quiescence even in the normal animal. Vigorous somatic movements frequently induce temporary cardiac arrest, followed by rebound acceleration when the movement ceases. Heart and somatic activity are, indeed, closely linked, and bursts of activity in the limbs of the almost anæsthetized animal are frequently followed by a brief return of activity in the already quiescent heart. The extent of this extrinsic control of the heart may perhaps be regarded as an essential feature of the neurogenic heart. The isolated heart of *Asellus* (author, unpublished) freed of control from the c.n.s. shows, by contrast, a very regular rhythm, like that of a myogenic heart *in situ*.

Myogenic Crustacean Hearts

The cladoceran *Daphnia*, unlike other Crustacea, has a myogenic heart[8] on Prosser's criterion. Both *Daphnia* sp. and *Simocephalus* sp. have been tested by the ether method, and Baylor's conclusion[8] is confirmed. In both, cardiac activity outlasts all other movement except that of the gut. Rate and amplitude eventually fall, but the regular rhythm of the myogenic heart is well sustained.

The anostracan heart was found to be insensitive to acetylcholine and was believed to constitute a third type, completely devoid of innervation[1]. On the present criterion, however, the heart of *Artemia salina* is myogenic as in the Cladocera. The sensitivity of the whole animal is again high, as in the Cladocera examined. The heart of *Diatomus*, one of the few cardiac copepods[9], is neurogenic on the present criterion as on that of Prosser[1]. Data on the response to ether of cardiac forms in other groups of 'Entomostraca', particularly among the Conchostraca and Notostraca, would be valuable, since on present evidence the myogenic heart seems peculiar to Phyllopods among Crustacea.

Diaptomus is unusually resistant to anæsthesia—considerably more so even than the acardiac copepod *Cyclops*. Further, it shows no appreciable cardio-somatic interval in the progress of anæsthesia. That its heart is essentially neurogenic, however, is shown by its erratic action, correlated with limb movements, in the later stages of anæsthesia. Recovery from anæsthesia is slow and uncertain in proportion to its high initial resistance. Ether is contra-indicated as an anæsthetic here.

Hearts of Other Invertebrates

Preliminary experiments indicate that the hearts of nymphs of *Cloëon* sp. and of an agrionid dragonfly are myogenic, like the hearts of other larval insects, on other criteria[2,10]. The relative resistance of the heart is higher than in the Phyllopod Crustacea examined. The response to ether of the heart of adult insects, usually neurogenic[1,11], has not been tested. The hearts of Mollusca are myogenic[1,2], and that of *Planorbis* sp. is very resistant to ether-water, even when admitted via a local 'window' in the shell. It appears to be more resistant than the (unstriated) foot musculature. Information on the response to ether of the hearts of molluscs, annelids[12], tunicates (possibly neurogenic[13] and therefore exceptional among Chordates) and other groups, would be useful.

Conclusions

Ether acts essentially on nervous mechanisms[6], and the relative sensitivity of the neurogenic heart is probably an indication of the high degree of control of this type of heart by the nervous system. With the dorsal ganglion removed the heart of *Limulus*[4] becomes 'myogenic'[6], with sequential replacing simultaneous beat.

The main differences between the two types of heart may be summarized:

Neurogenic	Myogenic
1. Nerve ganglion running the length of the heart[2]	Localized ganglion tissue or ? absent
2. Simultaneous contraction[2,3]	Sequential contraction
3. High degree of control by c.n.s.	High degree of automaticity
4. Relatively insensitive to acetylcholine[1]	Relatively sensitive to acetylcholine
5. Accelerated by acetylcholine[1]	Depressed by acetylcholine
6. More sensitive to ether than somatic systems	Less sensitive to ether than somatic systems
7. Striated muscle[2]	Derived from smooth muscle
8. Tetanizable[2,5]	Non-tetanizable
9. Normally shows rest-pauses	Incessant beat, normally

More evidence on comparative histogenesis and on tetanizability is probably required.

Some indication of the nature of the relationship between ether and acetylcholine has been given[14]. It seems probable that ether antagonizes acetylcholine directly or indirectly, progressively reducing its effective concentration at vital sites in the neuromuscular systems. The concentration first falls below the high threshold necessary for stimulation of the neurogenic type, which is therefore progressively slowed. The myogenic type is at first unaffected, while at still lower effective concentrations the normal *inhibitory* effect of acetylcholine on this type is relieved.

It does not seem essential, in order to explain the contrasted effect of acetylcholine on the two types of heart, to conclude[15] that the myogenic type is devoid of nerve cell-bodies, the anatomical evidence for which is rather negative[1]. The mammalian heart shows a variable and even paradoxical response to acetylcholine under different conditions[16,17], and the difference in response between myogenic and neuro-

genic hearts may therefore involve no fundamental anatomical difference.

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THE SCINTILLATION COUNTER

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WHEREAS the detection of alpha-particles in zinc sulphide screens by the visual observation of the individual scintillations which these particles produce dates back to the early spinthariscope of Rutherford and Crooks, the combined use of an appropriate scintillating phosphor and photomultiplier tube by Coltman and Marshall for alpha-particles[1], and by Broser and Kallmann for beta-particles and gamma-rays[2], heralded the new era of the scintillation counter. Since then, research workers in Great Britain, Canada and the United States have not been slow to appreciate the inherent possibilities of the new counting technique[3], and, as a result of the widespread enthusiasm which developed, there exists to-day in the hands of the nuclear physicist a new and extremely powerful instrument for the study of some of his many problems. That this is the case was very much in evidence at the scintillation counter conference held at Oak Ridge in June 1949. In particular, it has become possible to study the association in time of nuclear particles to within 10^{-8} sec.—and this is by no means the limit which can be attained—and to investigate the gamma-ray process with a detection efficiency many times that which is possible with the Geiger counter. Further, the operation of the device in a proportional sense permits entirely new investigations of the nuclear radiation from isotopes of extremely low specific activity. It is my main purpose here to review the important features of the method and then to indicate some of the more striking applications which have already been made.

The primary particle loses its energy in the phosphor by the excitation and ionization of molecules which may later be involved in the radiation of a fraction of this energy in the form of light. Thus with zinc sulphide – silver, for example, this fraction or 'physical' efficiency is approximately 27 per cent for alpha-particles, according to Kallmann[4]. The details of the exact mechanism and constitution of the phosphorescent centres in particular cases cannot be said to be clearly understood[5], and much work remains to be done to determine why the ratio of radiation capture centres for electrons freed from matrix ions to non-radiation capture centres is so large for certain phosphors only. More than this is required, however, for if the crystals should absorb strongly in the region of the spectral distribution of the radiated photons, then the 'technical' efficiency will be low and it will be possible to work only with thin layers of the material. Thus zinc sulphide is relatively opaque in layers greater than 80 mgm./cm.^{2}, and yet anthracene and sodium iodide – thallium appear to be almost completely transparent even in thicknesses of several centimetres. There also exists obviously the necessity for matching the sensitivity curve of the photomultiplier cathode with the distribution of the spectral emission of the phosphor.

We anticipate that the system will behave as a proportional counter if the technical efficiency is independent of the energy of the primary particle, and the crystal dimensions are large compared with the particle-range. Evidence has accumulated to show that this is certainly the case with sodium iodide – thallium[6] and anthracene[7], for beta-particles of 100 keV. to several million electron volts, but that heavy particles of similar energy will give smaller pulses in most cases. This difference in behaviour may be due to surface effects at the crystal, saturation or quenching effects due to high ionization density, or differences in the emission spectrum of the phosphor for particles of widely different masses. Kallmann has reported[4] that, for alpha-particles and a zinc sulphide screen, the pulse heights are proportional to energy down to 100 keV.

Other properties of the phosphor may be involved. The formation of metastable states in which the quanta are emitted over a fairly long period (greater than 100 microseconds for potassium iodide – thallium, for example, due to the nature of the trapping centres formed by the thallium) will mean that good resolution in coincidence experiments will not be attainable. The organic phosphors are supreme with respect to the rapidity of the light-emission process, and in particular anthracene (2×10^{-8} sec.), stilbene (8×10^{-9} sec.) and pyrene (less than 5×10^{-9} sec.) are among the fastest known phosphors[8]. These times represent the effective decay times of the pulse, the times for the rise being too short to measure with the equipment which was used. In order to obtain the greatest efficiency for the detection of gamma-radiation, the density of the crystal should be high and it should contain atoms of high atomic number; but whereas in this respect the inorganic phosphors such as cadmium tungstate (density 8, critical angle 28°) are desirable (Linde Air Products), the high refractive indices of some of these involve special problems in getting the light out of the crystal. Grinding the surfaces to help diffuse the light, or blooming, may help considerably in this respect. At the time of writing, it would probably be fair to say that the best phosphors available are thin layers of activated zinc sulphide or cadmium sulphide for alpha-particle detection; anthracene, stilbene, diphenylacetylene and pyrene for high-speed counting and coincidence counting; and sodium iodide – thallium and the tungstates for high gamma-ray efficiency where short resolving-times are not required. Tables of the properties of some of these materials were published recently[7]. One must, of course, always consider the ease with which a particular phosphor can be prepared, especially if a large single crystal is required.

The recent development in Britain of the *E.M.I.* 5311 photomultipliers and in the United States of

the *R.C.A.* 5819 tube has rendered much easier the whole problem of collecting light from the crystal on to the sensitive surface of the multiplier. These tubes have large semi-transparent cathodes which are mounted directly at one end of the inner surface of the glass envelope. The *R.C.A.* 931*A*, 1*P*21 and 1*P*28 tubes formerly made this problem a very difficult one, particularly for large crystals, because of the disposition and small size of the sensitive cathode surface. We have used the 5819 tubes in this way with crystals of several cubic inches in volume, without the need for resorting to the use of conical 'light pipes'. One feature of the 5819 operation which should be noted is its susceptibility to magnetic fields, which implies that a mu-metal screen should be used to avoid the effects of even the earth's field. In the region of a strong magnetic field, it may, however, be necessary to separate the multiplier and crystal, using a light pipe of lucite or quartz. In conjunction with a semicircular beta-ray spectrometer we have used lucite rods $1\frac{1}{2}$ in. in diameter and 2 ft. long, and at Berkeley the use of light pipes 12 ft. long has been reported by Wouters in the detection of very high energy electrons[5]. Collins has found quartz to be twice as good as lucite[6].

The *R.C.A.* 5819 tube may have a useful gain of the order of a few hundred thousand when used at 100 volts per operating stage. The multiplication process is liable to statistical fluctuations, however, and this matter must be given careful consideration when we come to deal with the use of the system as a proportional counter. Let us consider what might be a typical situation. A 500-keV. electron in a certain crystal phosphor produces, say, 10,000 photons, and one half of these are collected by the photocathode. Some small fluctuation in this number must be expected in view of the nature of the processes taking place in the crystal. If the photo-electron conversion efficiency of the cathode be 5 per cent, the number of photo-electrons will be 250, and will be liable to a deviation of approximately $\sqrt{250}$, or $6\frac{1}{4}$ per cent. Thus the deviation in the multiplier output voltage might be of the order of $6\frac{1}{4}\sqrt{\frac{1}{3}} = 7\frac{1}{2}$ per cent, giving a width to the distribution of pulse-height of 15 per cent, if we assume that the spread produced by the multiplication process itself introduces a factor $s/(s-1)$, where s is the secondary multiplication ratio of each dynode[5]. In any event, the effect has been shown to be relatively small when the number of photo-electrons from the cathode is large, as in this case[5]. It should be noted that it is essential to stabilize carefully the voltage supply to the multiplier, as the gain varies approximately as the seventh power of the voltage.

We have devoted some attention to the development of the scintillation counter as a gamma-ray spectrometer of low resolution[6], utilizing the nature of the relationship between secondary beta-particle energy and photomultiplier pulse-height output. Crystals of sodium iodide – thallium and 5819 photomultipliers have been used in this work, and the analysis of the pulses after suitable amplification has been achieved by means of a single-stage differential pulse-height selector, which counts only those pulses the amplitudes of which lie in a given range of pulse-heights. This circuit has a great advantage over the integral type of discriminator but will be replaced shortly by a five-channel differential instrument. If a gamma-ray of energy W_γ passes through a crystal, then Compton recoil electrons may be produced with all energies up to a maximum given by

$$W_c = W_\gamma \left(\frac{1}{1 - 0{\cdot}511/2W_\gamma} \right),$$

in addition to photo-electrons due to external conversion effects particularly in the iodine atoms in the lattice for gamma-rays of a few hundred thousand electron volts, and positive and negative electron-pairs for gamma-rays of high energy. The identification of this maximum energy W_c, due attention being given to the finite resolution of the equipment, will allow a measure of W_γ, as will the energy of the appropriate photo-electron peak (of energy $W_\gamma - W_K$) or pair-production peak (of energy $W_\gamma - 1{\cdot}02$ MeV.). In the region of energies up to 1 MeV. we have found it possible to resolve prominent photo-electron lines in the distribution curves (resolution 18 per cent at 400 keV.). From 1 MeV. to 2 MeV. the shape of the Compton distribution must, in general, be used to identify energies; but above 2 MeV. it is possible to resolve sharp peaks due to pair-production processes (resolution 8 per cent at 4·4 MeV.). (Some results by Johansson[10] have just come to our attention. These appear to give photo-electron peaks at an energy as high as 2·8 MeV. It is difficult to see how this can be so, in view of the very small yield of photo-electrons for $Z = 53$ at this energy.)

We have recently used the scintillation spectrometer[11] to measure the energy of the gamma-ray from potassium-40, and a value of $1{\cdot}47 \pm 0{\cdot}03$ MeV. has been obtained by comparison with the end-point of the distribution, substantially due to the Compton effect, for the 1·33 MeV. gamma-ray of cobalt-60 (Fig. 1). This result, taken in conjunction with certain theoretical conclusions, suggests that the energy of the *K*-capture process to the excited state of argon-40 is less than $0{\cdot}13 \pm 0{\cdot}03$ MeV. The background curve refers to the spectrometer when enclosed in a 3-in. lead castle. In our experiments, 90 gm. potassium chloride was used, a much smaller quantity than was required formerly in absorption measurements which gave a value of $1{\cdot}55 \pm 0{\cdot}05$ MeV. for the gamma-ray energy[12]. The photomultiplier noise-level becomes apparent at pulse-heights corresponding to approximately 20 keV., thus indicating a lower limit to the energies which can be studied without refrigeration[13].

Further interesting experiments have been conducted with the much-studied gold-198 isotope, and the existence of a rare (less than 1 per cent) high-energy gamma-ray of approximately 1·10 MeV. has been verified by a detailed comparison with the cobalt-60 end-point, as above[14]. A very prominent peak is due to the photo-electric conversion of the

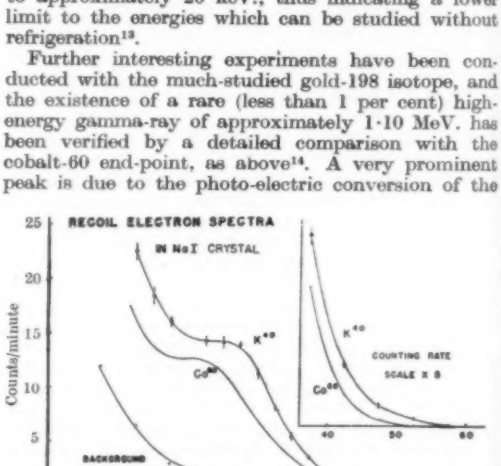

Fig. 1. Differential pulse-height distributions obtained with scintillation spectrometer. The curves for potassium-40 and cobalt-60 have been corrected for background

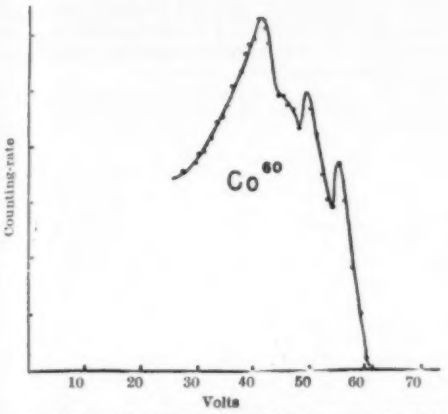

Fig. 2. Differential pulse-height distribution curve for highly collimated cobalt-60 gamma-rays, and a small sodium iodide crystal. The 1·17-MeV. Compton edge is well resolved, and also peaks due to combined Compton and photo-electric effects, for both the 1·17-MeV. and 1·33-MeV. gamma-rays

411-keV. gamma-ray in the crystal, as at this energy the photo-electron and Compton cross-section for iodine are comparable. Similar effects can be resolved above 1 MeV. if collimated rays and small crystals are used, as shown in Fig. 2, but for many investigations involving low-level gamma-ray intensities or coincidence work, such an arrangement is not desirable. In similar work, R. Hofstadter has obtained somewhat better resolution with an *E.M.I.* photocell (private communication). Experiments reported by us earlier[6], using large crystals, do not show the structure of Fig. 2. Some information has been obtained of the excited levels of carbon-12, produced in the Po α–Be reaction, by a study of the distributions due to the weak gamma-rays the energies of which we have measured as approximately 4·40 MeV. and 7·2 MeV. (see Fig. 3). Calibration of the energy-scale is made on the basis of the 2·62-MeV. gamma-ray of thorium C″. The source used for this calibration was 10 gm. of thorium nitrate, thus indicating the extreme sensitivity of the equipment. No substantial evidence is obtained here for gamma-rays from carbon-12 of energies in the range 2–4 MeV.

Work with the gamma-ray scintillation spectrometer is being pursued vigorously, and the co-operation of the Chemical Division of the National Research Council of Canada has been sought to obtain the purest materials for the study of possible gamma activities in members of the isobaric pairs of nuclei of neighbouring atomic number which occur in Nature. Work with less pure materials has shown up activities due principally to trace quantities of thorium. However, some particularly interesting results have been obtained with lanthanum-138, which exhibits a double anomaly and is one of the rare odd-odd type nuclei, and it is thought possible that this decays by *K*-capture to barium-138 with the emission of a gamma-ray of approximately 1·05 MeV.[15]. On this basis the half-life has been estimated as $\leqslant 1{\cdot}2 \times 10^{11}$ yr. In some of this work we have attempted to use cadmium tungstate as the scintillating crystal to obtain a more prominent photo-electric effect, but without much success.

Some interesting work has been done by Jordan and Bell at Oak Ridge, and a recent report[7] shows that some parallel developments are in progress there, particularly with regard to the use of a low-resolution beta-ray scintillation spectrometer in which anthracene has been employed. Sources a thousand times less active than those required by conventional spectrometers can be used.

To enter the millimicrosecond region of nuclear particle time-correlation studies will mean the discovery of many new facts about metastable states and will make possible accurate coincidence experiments for the elucidation of nuclear-level schemes, which could not be undertaken with Geiger counters. Some progress has been made[16] and various projects are under way in certain universities and research establishments. The 5819 photomultiplier gives a pulse output the width of which, due to transit time variations, is 5×10^{-9} sec.; but in Britain some success has been achieved by R. Kompfner of Oxford[4] in attempts to develop multipliers in which this variation is less by a factor of approximately 100. Wide-band distributed amplifiers are now available with a rise time of only 0·003 microsec. (Spencer Kennedy Laboratories, Cambridge, Mass.), but these may not be necessary if the fourteen-stage multipliers reported by Morton[8] eventually become available. These have a gain of 10^{11} and can produce pulses of some fifty volts for single electrons. A similar performance can be attained if experiments with pulsed multipliers are successful. Fast pre-scaling units with an input resolving time of 0·25 μsec. can now be obtained (Atomic Instruments Co., Boston) and are necessary for this work. Extremely fast coincidence circuits with a resolving time of 10^{-9}–10^{-10} sec. have been developed[17], but a simple and efficient system is to 'gate' the last stage of one multiplier by the output of the other. The resolving time of 5×10^{-9} sec. has been obtained by this procedure (Wouters[8]).

The crystals for use in this short time-interval region have already been indicated. We have attempted to combine some of these features with the proportional properties of the scintillation counter in the development of a coincidence scintillation spectrometer in which some of the difficulties of working discriminator units at extremely short resolving times are avoided. This unit can be used for beta-gamma or gamma-gamma coincidence studies with low resolution of energies, but a similar system in which the beta-energies are resolved in a semi-circular focusing spectrometer is also being used. A

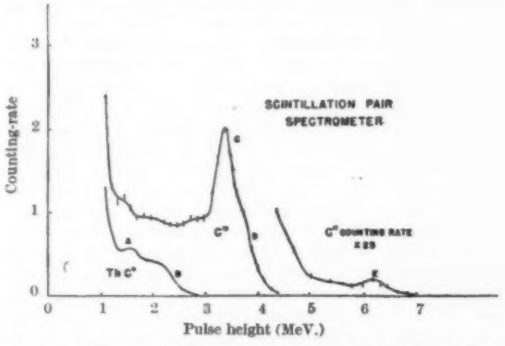

Fig. 3. Differential pulse-height distributions, showing the pair-production peaks obtained with high-energy gamma-rays. The thorium C″ 2·62-MeV. gamma-ray has been used to calibrate the pulse-height scale
(*A*) Pair production due to thorium C″ 2·62-MeV. gamma-ray.
(*B*) Compton edge due to thorium C″ 2·62-MeV. gamma-ray.
(*C*) Pair production due to carbon-12 gamma-ray (4·40 MeV.).
(*D*) Compton edge due to carbon-12 gamma-ray (4·40 MeV.).
(*E*) Pair production due to weak carbon-12 gamma-ray (7·2 MeV.).

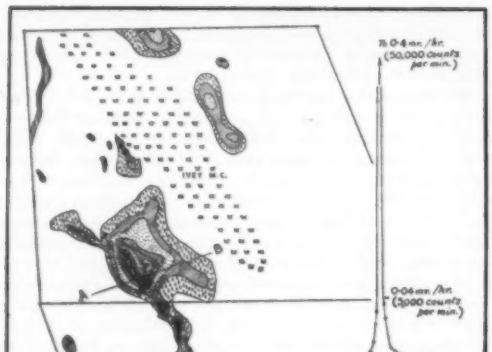

Fig. 4. Scintillation counter radiation survey at Goldfields, Saskatchewan. (Intensity zones indicated by varying pattern of shading)

large semi-permanent magnet is being employed for this work.

Many other interesting developments are taking place. At Berkeley some work has been accomplished in the detection of high-energy electrons by the use of anthracene probe counters in the 300-MeV. synchrotron for the location of the electron beam. Fast protons have been investigated in an absorption coincidence device which has also been used to measure the cross-sections of various elements for fast neutrons. Anthracene crystals have been used for the detection of fast neutrons by exposing the crystals to the neutron beam for a known time interval and then measuring the induced carbon-14 beta activity. A similar method has been investigated by us in which a sodium iodide – thallium crystal is exposed to slow neutrons and the induced beta-activity due to iodine-128 (25 min.) is observed. Anthracene can be used directly, however, for the study of fast neutrons, the scintillations being caused by the recoil protons produced in the crystal; this might lead to a method for the measurement of neutron energies, except that the high sensitivity to gamma-rays is a grave disadvantage. Some successful methods have been developed for the detection of slow neutrons either by the use of lithium fluoride or lithium iodide crystals[18,19]. It is interesting to note that Wouters has found that the photomultiplier tubes can be used by themselves to count neutrons with an efficiency of 0·01 per cent for 300-MeV. neutrons. He attributes the process to the local heating of the surface caused by recoil nuclei, and has observed similar pulses for neutrons from a radium–beryllium source of height smaller by a factor of twenty.

Applications of the technique to cosmic ray research have been made[20], but it is anticipated that much more will be heard of this aspect when very large transparent crystals are utilized. Some further results are worth noting. Hofstadter, using stilbene crystals, has verified the simultaneity of the recoil electron and scattered quantum in the Compton process to within 10^{-8} sec., and has verified the angular distribution of the scattered quanta as given by the Klein–Nishina formula[5,21]. Deutsch has devised a coincidence system to measure the half-life of the positron[5,22] and obtained a value of $1{\cdot}05 \pm 0{\cdot}1 \times 10^{-7}$ sec. at 1 atmosphere pressure with nitrogen, as a result of a study of delayed coincidences between nuclear gamma-rays from a positron-active sodium-22 source and the annihilation radiation produced on the disappearance of the positrons.

The advantages of the scintillation counter are not limited to their application to academic physics. The use of high-sensitivity gamma-detectors for radioactive tracer technology is one obvious development which will mean the use of much smaller doses than are used at present. Work in this direction is proceeding in the Medical Department of the University of Manitoba. Portable scintillation counters for geological field-work were developed for the first time in 1949 in Canada[23]. It was found possible to devise a portable instrument weighing no more than 10 lb. which has a detection sensitivity for radium gamma-rays of 5×10^{-11} r./sec. with a response time of 16 sec. One reason for this great increase over the sensitivity in detection of the Geiger counter is the relatively small part of the normal background (a few per cent) which is due to cosmic rays. Tests in the Lake Athabaska area of northern Saskatchewan during the summer of 1949 gave excellent results, and indicated unknown uranium deposits in areas previously closely surveyed by Geiger counters. Isorads, or lines of equal radiation intensity, can be plotted to delineate areas of geological interest (Fig. 4). Further, it is possible in the field to distinguish roughly between the effects due to thorium and uranium ores, because of the different gamma-ray spectra involved. A commercially developed model of this instrument has been produced by Halross Instruments, Ltd., Winnipeg.

Enough has been said to suggest that although a certain amount has been accomplished, further intensive research and study in this new field will continue to yield results of considerable interest and importance.

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NEWS and VIEWS

Mathematics at Nottingham : Prof. H. T. H. Piaggio

After forty-two years of service to the University College and, afterwards, the University of Nottingham, Prof. H. T. H. Piaggio is about to relinquish the chair of mathematics which he has held with such great distinction. Born in June 1884, he was educated at Lyulph Stanley School and the City of London School, and received his main mathematical training at St. John's College, Cambridge, during 1903–08. He was a Wrangler in 1906, and gained an honourable mention for the Smith's Prize in 1908. He took the London (external) B.Sc. degree with first-class honours in 1905, and this paved the way for the award of the London D.Sc. in 1914. After short periods of service at Battersea Polytechnic and with the Secondary School of Woolwich Polytechnic, he went to Nottingham as a junior lecturer and was eventually promoted professor in 1919.

In Nottingham Prof. Piaggio has built up a great reputation as a first-rate teacher of mathematics; he has probably had a smaller percentage of unsuccessful degree candidates than any other university teacher of mathematics. His book on differential equations is a model of its kind, which has run into twenty editions and has been translated into several languages. He is well known for his researches on the algebra of invariants and, of course, on differential equations, and many readers of *Nature* must have enjoyed his clear expositions of relativity matters and his pithy reviews of mathematical works. Prof. Piaggio will be much missed by his colleagues, who have found in him a wise counsellor, and a loyal and cheerful colleague who has been known to do many a kind act by stealth. He will take with him wholehearted good wishes for a happy and active retirement in which he may still enjoy many a good game of chess.

Prof. H. R. Pitt

Prof. H. R. Pitt, who will succeed Prof. Piaggio in January 1951, went to Cambridge, where he took his B.A. degree with distinction in 1935. He then began research under the late Prof. G. H. Hardy, and in 1936 was elected a bye-fellow at Peterhouse. In 1937 he gained a Smith's Prize and then spent a year at the Massachusetts Institute of Technology under Prof. Norbert Wiener. After taking a Ph.D. at Cambridge, Prof. Pitt spent two years as assistant lecturer at Aberdeen, and then three years in operational research at the Ministry of Aircraft Production and the Air Ministry; he reached the grade of senior scientific officer before his retirement in 1945. Since then he has been professor of mathematics in Queen's University, Belfast, where he has earned a high reputation both for teaching and the direction of research. Prof. Pitt has published a large number of papers on mathematical analysis, which have appeared in the *Journal for Mathematics and Physics*, *American Journal of Mathematics*, *Duke Journal*, *Journal and Proceedings of the London Mathematical Society* and the *Proceedings of the Cambridge Philosophical Society*. These deal with Fourier series, Tauberian theorems, Mercerian theorems, integro-differential equations, and similar topics. Although Prof. Pitt's chair is that of pure mathematics, and his published work is primarily in that field, much of it has applications to physics and statistics, of which he has a keen appreciation, believing that pure and applied mathematics are best treated in a unified way as two aspects of the same discipline.

Chemistry at the University College of North Staffordshire : Prof. H. D. Springall

Dr. H. D. Springall, who has been appointed to the chair of chemistry in the University College of North Staffordshire, has a wide chemical interest and experience, and possesses the rare distinction of an equal facility in both the organic and physical aspects of chemistry. He gained an open scholarship at Lincoln College, Oxford, in 1930, and graduated with first-class honours in 1934. Appointed to a senior demyship at Magdalen College at this time, he carried out researches on the molecular structures of organic compounds under Prof. N. V. Sidgwick, and on the steroid hormones under Sir Robert Robinson, and was awarded the D.Phil. degree in 1936. His early interest in structural chemistry was rewarded by his appointment to a Commonwealth Fund fellowship, during the tenure of which he worked with Prof. Linus Pauling at Pasadena. He returned to Oxford in 1938 to continue his association with Sir Robert Robinson in studies on the chemistry of proteins. On the outbreak of the Second World War, Dr. Springall became a scientific officer to the Ministry of Supply (Armament Research Department) and moved to the University of Bristol to work under Prof. E. L. Hirst. He was appointed a senior scientific officer in 1944 and was transferred from Bristol to Manchester in 1945.

After the War, Dr. Springall returned to academic work as lecturer in chemistry at the University of Manchester, where later (1948) he was appointed senior lecturer. His researches in recent years have been concerned mainly with the physical aspects (dipole moments, molecular structure and heats of combustion) of organic molecules; but his interest in the chemistry of proteins has remained, and his book on this subject is in course of publication. Dr. Springall's abilities as a lecturer, both to students and in his extra-mural courses, and his work as tutor at Dalton Hall have been widely appreciated at Manchester. A man of wide cultural background (who includes mountaineering among his various hobbies), he combines a varied experience with a great personal charm that has gained him many friends, and which should guarantee the successful growth of a new school of chemistry at the new University College.

The Premio Europeo Cortina Prize : Prof. John Read, F.R.S.

Prof. John Read, in acknowledgment of the award to him of the Premio Europeo Cortina Prize, visited Italy in May, under the auspices of the British Council, and delivered lectures in Turin, Milan, Pavia, Padua, Verona, Trento, Parma, Ferrara, Bologna, Florence, Rome and Naples. The lecture most in demand dealt with "La Storia della Scienza come Strumento di Cultura" (Historical Science as an Instrument of Culture"), and he spoke also on some modern researches in terpene chemistry and stereochemistry. Italian men of science, both academic and industrial, expressed great appreciation of the visit, and showed a common eagerness for a closer cultural association between Italy and Great Britain. In Rome, Prof. Read was invited to lecture not only in the University but also in the celebrated Palazzo Venezia. In several centres he established cordial contact with the Italian Chemical Society, which sponsored some of the meetings.

New Unstable Cosmic Ray Particles

In an important paper (*Phys. Rev.*, **78**, 290; 1950), Prof. Carl Anderson, of the California Institute of Technology, together with four colleagues, A. J. Seriff, R. B. Leighton, C. Hsiao and E. W. Cowan, presents conclusive evidence for the existence of two new unstable cosmic ray particles. Using a counter-controlled cloud chamber in a magnetic field of 6,500 gauss, 3,000 photographs of penetrating events were made near sea-level and 8,000 at an altitude of 3,700 m. In all, 34 'forked tracks' were found, similar to the two photographed in Manchester by Rochester and Butler (*Nature*, **160**, 855; 1947), and interpreted by them as representing the decay of neutral and charged unstable particles of a new type and of mass around 900 electron masses. Of Anderson's 34 forked tracks, 28 were due to the decay of neutral particles and 6 to the decay of charged particles. The mass of the unstable particles was estimated as probably between 250 and 400 electron masses greater than the sum of the masses of the decay products. It was further suggested that perhaps all the particles may not have the same mass. Evidence is provided that at least some of the decay products are nuclear interactive and are thus most probably π-mesons, or conceivably protons.

From the distribution of decay processes across the chamber, the life-time of the neutral particle was determined as $(3 \pm 2) \times 10^{-10}$ sec., and some evidence was obtained which indicated a considerably shorter life for the charged particles. These figures show that Rochester's and Butler's crude estimate of life-time, based on only two examples, was too high by a factor of over a hundred. These new particles are certainly so massive as to put their artificial production in the laboratory at least a few years in the future. Thus the accurate determination of the masses and life-times of the particles, and of their possible relation with other reported examples of very heavy mesons decaying in a different manner or not decaying at all (Brown, *et al.*, *Nature*, **163**, 87; 1949. Harding, *Phil. Mag.*, **41**, 405. Leprince-Ringuet, *Rev. Mod. Phys.*, **21**, 42; 1949. Butler, Barker and Rosser, *Phys. Soc.*, **63**, 145; 1950), will remain a major task of cosmic ray research in the next few years.

National Collection of Industrial Bacteria

A national collection of industrial bacteria was begun at the Chemical Research Laboratory (Department of Scientific and Industrial Research) early this year. It took over the non-pathogenic cultures held by the National Collection of Type Cultures at Colindale, and now houses some three hundred and fifty types. This number is expected to increase considerably as the Collection becomes more representative of the needs of industry. The Laboratory will maintain any organism which has ceased to be of interest but which may be wanted later. It frequently happens that a particular organism is destroyed when it has fulfilled its temporary purpose and yet may be required in the future at short notice. The Laboratory will also maintain any organism which for one reason or another should be duplicated. Most of the non-pathogenic bacteria supplied up to now by Colindale can be obtained from the Chemical Research Laboratory, and the Laboratory will try to procure any type of non-pathogenic culture which it does not hold itself. In time, it is hoped that the collection will become comprehensive, and gaps are being filled by obtaining cultures from other laboratories in Great Britain and abroad. Particular emphasis will be given to assay organisms. Cultures held by the Collection will be included in the United Kingdom List of Species to be published in 1951. Inquiries should be addressed to the Director, Chemical Research Laboratory, Teddington, Middlesex.

The Brotherton Collection, University of Leeds

The fourteenth annual report of the Committee for the Brotherton Collection of the University of Leeds, covering the session 1948–49 (pp. 9; Leeds: the University, 1950), records the contents of the Collection on June 30, 1949, as 22,887 books, 15,642 pamphlets, 477 manuscripts, 4,105 deeds, 31,251 letters and 25 maps. The first public exhibition of the session was arranged in connexion with a visit of delegates to the International Geological Congress held in London, while another exhibition, on the history of printing, illustrated lectures at the Leeds College of Art and the Department of Printing of the Leeds College of Technology. Visitors during the session numbered 850, including twenty-eight organised parties. A list of acquisitions is given in the report.

Newfoundland Biological Station for Fishery Research

Fisheries research in Newfoundland, which was formerly the responsibility of the Newfoundland Government Laboratory, is now being carried on under the Fisheries Research Board of Canada. The name of the Laboratory has been changed to that of the Newfoundland Biological Station. This Station will in future carry on work in marine biology and hydrography only. With Bulletin No. 18 ("Lobster Investigations in Newfoundland, 1938–1941", by W. Templeman and S. N. Tibbo), bulletins of the Newfoundland Government Laboratory will come to an end, and publication in future will be through the *Journal*, bulletins and other publication channels of the Fisheries Research Board of Canada. The new address of the Laboratory will be the Newfoundland Biological Station, St. John's, Newfoundland. We wish the Station every success under the new regime.

Conference on Civil Engineering Problems in the Colonies

A conference on civil engineering problems in Colonial territories will be held at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, during July 3–7. This is the second such conference to be organised by the Institution, and, following the successful one held at Oxford in 1948, it has been decided to make it a biennial event. These meetings are intended primarily to meet the needs of civil engineers in the Colonial engineering service. The programme consists of technical sessions, when papers are presented and discussed; visits to engineering works; and a reception at the Institution on July 7. One of the technical sessions is being devoted to "Engineering Research and the Colonial Engineer", when short lectures from the directors of the Road Research Laboratory, Forest Products Research Laboratory, Hydraulics Research Organisation, Building Research Station, and the Water Pollution Research Laboratory will be given. It is intended to publish, in due course, the proceedings of the conference, which will contain all the papers and lectures presented, together with the discussions thereon. Attendance at the conference is not limited to members of the Institution of Civil Engineers, and non-members desirous of attending should apply to the secretary of the Institution.

University of London

THE title of professor emeritus of zoology in the University of London has been conferred on Prof. A. J. Grove on his retirement from the chair of zoology at Queen Mary College, where he has been an 'appointed teacher' since 1933; the title of professor of pharmacology in the University has been conferred on Dr. J. M. Robson in respect of the post held by him at Guy's Hospital Medical School. Dr. G. Brownlee has been appointed to the University readership in pharmacology, tenable at King's College. The degree of D.Sc. has been conferred on W. Ehrenberg (Birkbeck College) and L. N. Owen (Imperial College of Science and Technology).

Royal Statistical Society: Election of Officers

AT the annual general meeting of the Royal Statistical Society the following elections were announced: *President*, Prof. Bradford Hill; *Honorary Secretaries*, Mr. R. F. George, Mr. Richard Stone, Mr. Philip Lyle; *Honorary Treasurer*, Mr. R. F. Fowler. Mr. H. Campion, of the Central Statistical Office, was awarded the Society's Guy Medal in silver.

The Night Sky in July

NEW moon occurs on July 15d. 05h. 05m., U.T., and full moon on July 29d. 04h. 17m. The following conjunctions with the moon take place: July 4d. 03h., Jupiter 1° N.; July 12d. 12h., Venus 6° S.; July 19d. 08h., Saturn 0·8° N.; July 21d. 18h., Mars 1° N.; July 31d. 09h., Jupiter 0·9° N. Mercury is a morning star at the beginning of the month, but, as it rises only forty minutes before the sun on July 1 and is in superior conjunction on July 11, it is too close to the sun for observation during the month. Venus rises nearly two hours before the sun throughout July and can be seen in the eastern sky in the early morning hours, stellar magnitude −3·4, the visible portion of the illuminated disk varying between 0·805 and 0·882. Mars sets at 23h. 40m., 22h. 55m. and 22h. 05m. on July 1, 15 and 31, respectively, and can be seen in the constellation of Virgo for a short time before sunrise. In the early part of the month it is a little north of δ Virginis, and at the end of the month a little north-east of α Virginis. Jupiter rises at 22h. 55m. and 20h. 55m. on July 1 and 31, respectively, and can be seen about midway between λ and θ Aquarii, but a little south of the line joining them. The declination of the planet is about −9°, so that it does not attain a greater altitude than 30° in the latitude of Greenwich; this maximum altitude is reached in the third week of July about an hour before sunrise, and the planet is too low during the month for very favourable observation. Saturn, which is close to σ Leonis, sets at 23h. 10m. on July 1 and at 22h. 15m. on July 15, but after this it draws too close to the sun for favourable observation, setting 1h. 25m. after the sun on July 31. Only one occultation of stars brighter than magnitude 6 takes place during the month, ω Sagittarii reappearing on July 1d. 02h. 07m. The earth reaches aphelion on July 3.

Announcements

SIR IAN HEILBRON, director of the Brewing Industry Research Foundation and formerly professor of organic chemistry in the University of London (Imperial College of Science and Technology), has been elected a foreign member of the Royal Netherlands Academy of Sciences and Letters.

SIR HENRY TIZARD has asked the Minister of Defence to be relieved of part of his responsibilities as scientific adviser, and will continue work on a part-time basis. Sir Frederick Brundrett, chief of the Royal Naval Scientific Service, has been appointed deputy scientific adviser to the Minister of Defence. Sir Henry Tizard will continue to be chairman of the Defence Research Policy Committee.

THE Mixed Commission of Radiobiology, under the auspices of the International Council of Biological Unions, will hold a meeting at the Bibliothèque de l'Institut du Radium, 26 rue d'Ulm, Paris 5e, on July 16, at 5 p.m. The provisional programme will include: the election of a president and a secretary; information and publications on radiobiology; organisation within the United Nations; radiobiological teaching and research; standardization of animal stocks and of biological material; and radiobiological units. This meeting has been made possible by a grant from Unesco. The secretary of the Commission is Dr. P. Bonet-Maury, Laboratoire Curie, 11 rue Pierre-Curie, Paris 5e.

THE fifth annual electronics exhibition organised by the North-Western Branch of the Institution of Electronics will be held at the College of Technology, Manchester, on July 18, 2.30 p.m.–9 p.m., and during July 19–20, 10 a.m.–9 p.m. Part of the exhibition will be devoted to the interests of the amateur constructor, and there will be demonstrations of television reception on receivers designed for home construction. Admission will be by ticket obtainable from Mr. A. Hickson, 205 Parrs Wood Road South, East Didsbury, Manchester 20.

A DAY conference on "Clay Minerals, with Special Reference to Moulding Sand Bonds" will be held in the Department of Coal Gas and Fuel Industries, University of Leeds, on July 7, beginning at 10 a.m. Papers will be given by Dr. R. E. Grim, geologist and head of the Division of Clay Resources and Clay Mineral Technology, State Geological Survey Division, Illinois, and by Prof. A. L. Roberts and Dr. R. W. Grimshaw, of the University of Leeds. The papers will be followed by discussions and demonstrations. Attendance fee for the conference is 10s. Further particulars may be obtained from Miss M. Spink, assistant to the Director of Extra-Mural Studies, University, Leeds, 2.

THE Medical Research Council invites applications for the Kathleen Schlesinger Fellowship, tenable initially for one year at the National Hospital for Diseases of the Nervous System, Queen Square, London, and worth £700–£1,000 a year. This fellowship is provided from a fund established by the late Mr. E. M. Schlesinger and Mrs. Schlesinger in memory of their daughter; it is for the investigation of the origin and nature of cysts of the brain, and preference will be given to candidates who elect to work on the mechanisms underlying degenerative processes affecting the brain. Applications must reach the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, not later than July 15.

ERRATUM. In *Nature* of June 3, p. 868, in a notice of "Biology and Man", it is stated that the author is senior biology master at Winchester College; Dr. F. G. W. Knowles is, in fact, senior biology master at Marlborough College.

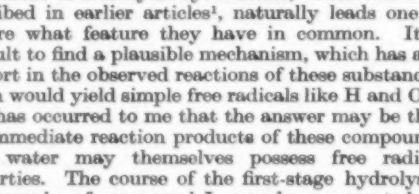
NATURE OF NUCLEOTOXIC SUBSTANCES

By Dr. J. A. V. BUTLER

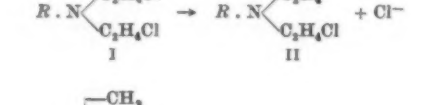
Chester Beatty Research Institute, Royal Cancer Hospital, London

THE close similarity of the actions on deoxyribonucleic acid of nitrogen and sulphur 'mustards' with those of free hydroxyl radicals, which has been described in earlier articles[1], naturally leads one to inquire what feature they have in common. It is difficult to find a plausible mechanism, which has any support in the observed reactions of these substances, which would yield simple free radicals like H and OH.

It has occurred to me that the answer may be that the immediate reaction products of these compounds with water may themselves possess free radical properties. The course of the first-stage hydrolysis, for example, of compound I, may be represented by the following sequence of reactions[2]:



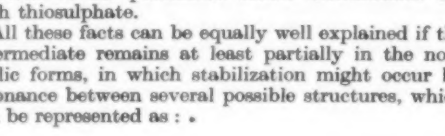
I II



III IV

The evidence on which this is based is: (1) the appearance of Cl^- in the solution prior to the liberation of an equivalent amount of H^+; (2) the subsequent liberation of H^+; (3) the instantaneous reaction of the postulated stable intermediate III with thiosulphate.

All these facts can be equally well explained if the intermediate remains at least partially in the non-cyclic forms, in which stabilization might occur by resonance between several possible structures, which can be represented as:



V VI VII

The existence of such forms easily explains the well-known dimerization reactions[3] and the condensation reactions with such molecules as cysteine, methionine, hexamethylene tetramine and pyridine, which occur so readily[4]. A resonance hybrid of this kind has been suggested for ethylene oxide and similar molecules[5].

Electron displacements of the type V → VII, in which the electrons of a lone pair are donated to an appropriate acceptor atom, have been suggested[5] to account for a number of different types of organic rearrangements; for example:

$$R_3N + CH_2 . Br \rightarrow R_3\overset{+}{N} . CH_2 + Br^-.$$

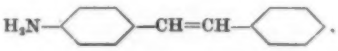
It is to be expected that the carbonium ion in V will act as a powerful acceptor. Form VI is potentially a double radical and to it the radical-simulating properties may be due.

Everett and Ross[6] have shown that when *R* in (I) is an aromatic substituent, the Cl^- and H^+ are liberated together, so that there is in these cases no evidence of any long-lived intermediates between I and IV. This must be regarded as evidence of the lesser stability of form VI; but the biradical form may be present to a sufficient extent to influence the reactivity. It may be significant that the toxicity of these compounds is relatively low.

It has been shown that in these compounds and in the sulphur analogues two halogen groups are normally necessary to produce biological activity. This has been interpreted in various ways, such as the ability of the two-armed halides to act as cross-linking agents[7]. The above considerations suggest that the function of the second halogen atom may be to assist in stabilizing the 'radical' form VI. It may do this by reducing the binding energy of electrons in the central nitrogen or sulphur atom, so that an electron can be more readily donated to the terminal carbonium or by giving rise to additional resonance possibilities.

On the view suggested, the occurrence of radical-like forms in these compounds would depend primarily on the relative strengths of the electron bindings in the various structures. It would follow from this, however, that *two* halide groups may not be invariably necessary for the appearance of this behaviour, if the energy requirements can be met in other ways.

It is interesting to note that most of the known nucleotoxic substances can give rise to similar structures; but it must be emphasized that their occurrence and stability will depend on the energy relationships and not merely on the formal possibilities. Any double bond might be 'activated' in this way; whether it is depends on the nature of the molecular orbitals and the electron densities produced around the different atoms. For example, in the case of 4-amino-stilbene,



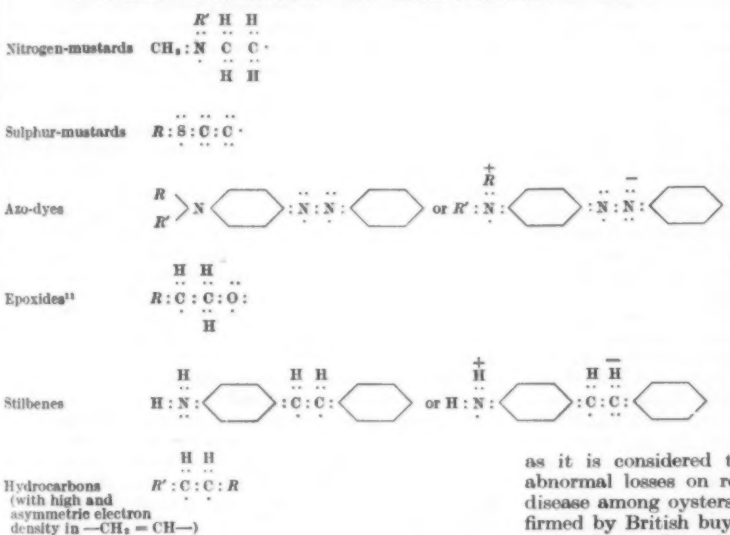
it has been shown by Coulson and Jacobs[8] that the charge distribution in the double bond is markedly asymmetric "resulting in reduced bonding and a greater proportion of the electrons free to initiate reactions". Also it has been suggested by Daudel[9] and by Mme. Pullman[10] that there is in the polycyclic hydrocarbons a region of high electron density termed by them the *K*-region, to which they ascribe the carcinogenic properties of these compounds; the biological activity is correlated by them with a certain optimum value of the electron density. (According to the calculations, this concentration is unequally distributed between the two active atoms.)

The essence of the requirement may be its asymmetry, resulting in potential radical forms in the region in question.

The accompanying list shows the crude conventional formulations of most of the types of compounds in which nucleotoxic properties of various kinds (either carcinogenicity, or mutagenic properties, or both) have been reported. It can be seen that they are all capable of biradical formulation. The actual structures will be hybrids of the possible forms, and the prominence of radical-like properties and reactivity will depend on the energy relations and particularly on the symmetry of the molecules. It must also be noted that other biradical forms are possible; for example, in the azo-dyes the amino-nitrogen has a lone pair of electrons, of which one might be donated to the diazo-group. These possibilities could only be distinguished by a very exact knowledge of the molecular structures.

As a final illustration, we may observe that, according to the theories of colour and fluorescence proposed by G. N. Lewis, all molecules with double bonds have excited states in which one of the double bonds is broken. It is suggested that these states are biradicals with one pair of electrons having parallel spins[12]. In support of this it has been shown that fluorescein when irradiated with blue light becomes paramagnetic[13]. It is therefore of interest to find that G. Oster has observed[14] that *ribonucleic* acid is degraded by blue light, in the presence of the fluorescent dye, acriflavine, and tobacco mosaic virus is also inactivated by this treatment. This may be regarded as a confirmation of the nucleotoxic effect of biradicals formed by irradiation.

BIRADICAL FORMS OF SUBSTANCES WITH VARIOUS NUCLEOTOXIC PROPERTIES



This and the previous investigation have been assisted by grants to the Royal Cancer Hospital from the British Empire Cancer Campaign, the Jane Coffin Childs Fund for Medical Research, the Anna Fuller Fund and the Division of Research Grants of the U.S. Public Health Service.

I am also greatly indebted to Profs. A. Haddow and G. A. R. Kon, and to Dr. W. C. J. Ross, for discussions which have helped me to clarify some of the points mentioned above.

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SHELL DISEASE IN RE-LAID FRENCH OYSTERS

By DR. H. A. COLE

Fisheries Experiment Station, Conway, Caernarvonshire

SHELL disease in oysters has been prevalent in the Netherlands for many years and was the cause of serious mortalities in the years following 1930[1]. A full account of this disease has never been published; but at the special shellfish meeting of the International Council for the Exploration of the Sea, held at Edinburgh in October 1949, Dr. P. Korringa presented a paper giving a summary of his work and brief details of the method of control now employed in the Netherlands.

In this paper, and in private communications, Korringa states that he has several times observed undoubted shell disease, identical with that occurring in the Netherlands, in French oysters offered for sale by planters in Brittany. Great care is apparently taken by Dutch importers to avoid the purchase of such infected stocks, as it is considered that the disease may lead to abnormal losses on relaying. The presence of this disease among oysters in Brittany was recently confirmed by British buyers, the shells being submitted to me for confirmation.

Giard[2], Hornell[3] and Ranson[4] have recorded the existence of a disease among French oysters, commonly referred to as 'maladie du pied', which appears to be similar in its effects to Dutch shell disease. Further investigations may show that they are identical. Orton[5], on the other hand, in a review of the literature, concluded that the disease 'maladie du pied' could not be clearly defined, and that the

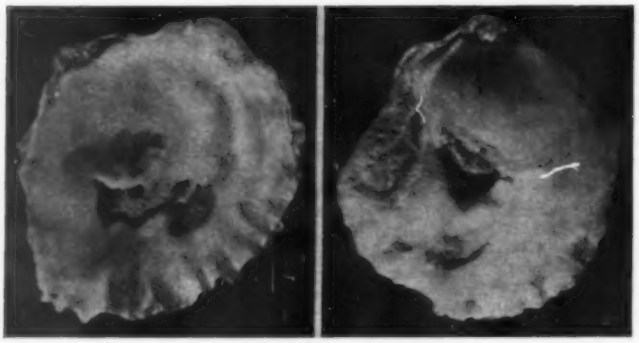

Fig. 1. The disease invading the area of muscle attachment
Fig. 2. The muscle scar very seriously affected and the shell margin distorted

published accounts would not bear critical examination. Judging by the literature, 'maladie du pied', although widely observed among stocks of French oysters, does not usually cause serious losses.

There is no record of the occurrence of shell disease in Britain. Orton, after an exhaustive examination of diseased, or alleged diseased, oysters from practically all the oyster beds of commercial importance in Britain, found that brown 'excretory deposits' were of rather frequent occurrence on the shell of both weak and normal oysters. He concluded that they were of little importance.

During the course of the past fifteen years, I have opened and examined, for a variety of purposes, many thousands of oysters from all parts of Britain, including substantial quantities of re-laid French oysters, but not until recently had I been able to detect with certainty the presence of shell disease. On December 5, 1949, of fifty re-laid French oysters taken from the Menai Straits oysterage, two showed advanced shell disease, in each case affecting the shell beneath the adductor muscle; the cupped valve of one of these oysters is shown in Fig. 1. The consignment of oysters, from which these fifty were a random selection, was laid down direct from France in April 1949 in the region of low water of spring tides. A second sample of fifty, collected on December 21 from the same bed, yielded two with undoubted shell disease and a third suspect; one of the affected oysters was in very poor condition.

A further example of shell disease was found on December 13 by an oyster planter when examining some weak or dead oysters thrown out from various consignments received at the London depot of the company. In this case the oyster was gaping and the shell and adductor muscle were very severely affected; the cupped valve is shown in Fig. 2. As oysters are received at this depot from various beds in Cornwall, Kent and Essex, it was impossible to say with certainty from which area it was received, but it was undoubtedly a French oyster imported and re-laid in 1949.

I have since examined samples of French oysters, imported last year, from all the more important centres of oyster culture in Great Britain. The percentage showing shell disease varied between 4 and 30, but shells with the disease in an advanced stage were not common.

Such seriously diseased oysters cannot have been frequent among imported stocks in past years, for they would have been reported earlier. Further, close examinations (for another purpose) of the 'clocks' of many recently dead re-laid French oysters from our beds in the Roach River, Essex, have been made from time to time without disclosing any so seriously affected by shell disease as to be noticeable. A recent careful examination of native brood oysters and spat from a ground in the River Roach, on which French oysters have been laid thickly for two years, did not reveal any evidence of shell disease.

On our Menai Straits grounds, and in the Helford River, Cornwall, and probably elsewhere, many oysters may be found with dendritic white markings in the shell, usually in both valves, which simulate the early stages of shell disease. These markings, which are probably the result of infection by a fungus related to that causing shell disease, have never been known to lead to any serious after-effects, loss of condition, or mortality. Dutch shell disease, on the other hand, disfigures the inside of the shell by the production of extensive brown patches and warts, and leads to serious loss of condition, and, ultimately, death, when the disease reaches the muscle attachment.

French oysters, presumably including a proportion affected by shell disease, have been laid down on British beds in large quantities during the past fifteen years, and have, generally speaking, done very well and proved of great value for re-stocking depleted grounds. The occurrence this season of noticeable shell disease, with the serious secondary effects on the shell and adductor muscle, suggests that the British buyers were unlucky to include among their purchases in 1949 some heavily infected oysters. Korringa's investigations have shown that the disease spreads rapidly in hot summers, and the oysters imported in 1949 were presumably affected in the warm summer of 1947. The reported heavy production and consequent overcrowding on Brittany oyster beds may also be a contributory factor.

The exceptionally hot summer of 1949 may have led to a further spread of the disease in Brittany, and the effect of this will be noticeable in 1951 when the young oysters infected in 1949 reach a saleable size. Particularly careful examination of stocks offered for sale will therefore be necessary during the next few years.

Previous experience suggests that there is little likelihood of Dutch shell disease spreading on British beds from the comparatively small numbers of seriously infected oysters now present; but clearly every care should be taken in future to avoid the importation of diseased stock. The progress of the disease on British beds should be carefully observed.

In presenting this note I am much indebted to Dr. P. Korringa, Bergen-op-Zoom, for confirming my diagnosis of shell disease, and for much helpful information and correspondence.

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GAUSSIAN APPROXIMATIONS TO WAVE FUNCTIONS

By Dr. R. McWEENY

Chemistry Dept., King's College, University of Durham, Newcastle upon Tyne

In a recent paper[1], Boys proposes a general method of building up variational approximations to atomic and molecular wave functions from the members of a "complete class of Gaussian functions". Some time ago I made an independent investigation along somewhat similar lines[2], and it is the purpose of this communication to examine briefly the whole approach in the light of experience gained in this previous work.

Boys takes as his basic system the class of functions $\{x_A^l y_A^m z_A^n \exp(-a r_A^2)\}$, where

$$r_A^2 = (x-X_A)^2 + (y-Y_A)^2 + (z-Z_A)^2,$$

A being a variable point in space, l, m, n any integers, and a a variable parameter. Such a class contains an infinite number of complete Hermitian systems about every point A. Boys then forms "detors", that is, antisymmetrized products of ortho-normal one-electron functions formed from this class, each combined with a spin function. A large number of such detors would effectively span the entire representation space of the n-electron problem; but in practice, of course, the number used must be severely restricted by careful selection. In fact, hitherto, it has usually been the custom, when using more conventional function systems, to employ only one detor or, when configurational degeneracy exists, a small number of detors: the approximate eigenvector resulting from a variation treatment is then necessarily of limited accuracy, being confined to a certain subspace of the complete n-electron product space. The possibility of proceeding more generally has usually been regarded as prohibited, when the detors are based on hydrogen-like one-electron functions, by the difficulty of evaluating matrix elements of the Hamiltonian between such detors; this difficulty is removed if the one-electron functions are written in Gaussian form, all integrals involved then being expressible in relatively simple terms. It thus appears feasible that one might construct wave functions of great accuracy by applying the usual variation treatment to a linear combination of suitably chosen Gaussian detors.

Briefly, the novelty of the method arises from the particular choice of function system: it gives great liberty in selecting suitable functions, and it makes possible the use of more detors than usual by circumventing integration difficulties. No application of this general method has yet been published. In a treatment of the beryllium atom[3], it is possible to use detors based on hydrogen-like functions; but since, with suitable screening constants, these are already particularly good basic approximations, the difficulty of making a good selection of functions is evaded.

In constructing molecular wave functions it is impossible to make progress by this method unless one uses Gaussian functions. Our work has much in common with that of Boys, except that the whole problem was formulated and discussed in momentum space. Our conclusion was that, in spite of the elegance of the method, its ultimate value is doubtful simply because the Gaussian function is an appallingly bad substitute for the hydrogen-like function, from which detors would ideally be constructed. It will, however, be of great interest to see how far the method can be pressed; we shall therefore briefly present certain of our results. Using Gaussian functions, the choice of the most satisfactory members of the set proves to be both critical and difficult; the selection technique therefore becomes vital to the whole method if, as indeed is essential, the number of basic functions is to be reduced to a minimum.

Since our calculations were performed throughout in momentum space, it is first necessary to point out that the one-electron wave function $\psi(\mathbf{r})$ in co-ordinate space and the corresponding $\chi(\mathbf{p})$ in momentum space are identical in form provided this form is Gaussian; for Fourier transformation of such a function simply produces a similar function with different parameters. This means that a Gaussian wave function would, for some purposes, be of great practical utility owing to its simple transformation properties. (Usually it is impossible to obtain a momentum distribution function from an *accurate* co-ordinate space wave function[4,5].)

The eigen value equation for the bound states of one particle in an arbitrary central field can be solved fairly easily in momentum space[2] to any degree of accuracy, using a Gaussian variation function. As in co-ordinate space, the variation treatment involves calculating diagonal matrix elements of the kinetic and potential energy operators with a variation function $\chi(\mathbf{p})$; we shall denote these by $\overline{T}$, $\overline{V}$. It is usually possible to represent the general potential (V) adequately as a combination of a few terms of Gaussian (V_G), and Yukawa ($V_Y = (\exp-\varkappa r)/r$) (including Coulombic) form. Taking the basic Gaussian term as $V_G = \left(\frac{\pi}{t}\right)^{3/2} \exp\left(-\frac{r^2}{4t}\right)$, and defining the integral operator

$$I(t,x) = \int_0^\infty dt \exp(-x^2 t) \ldots,$$

it is readily shown that $\overline{V}$ may be obtained easily from $\overline{V}_G$, for $\overline{V}_Y = (2\pi^2)^{-1} I(t,\varkappa)\overline{V}_G$: moreover, with a Gaussian variation function both $\overline{T}$ and $\overline{V}_G$ are elementary integrals.

Here then is a simple method by which one-particle wave functions for various fields may be determined directly in Gaussian form; the method has been applied to the deuteron[6], using the Yukawa potential, and to other problems, including the hydrogen-like atom[2]. This latter application gives a first indication of which functions should be selected in building up Gaussian detors in the more general n-electron problem. With this type of problem in mind, the following general conclusions and numerical illustrations (contained in ref. 2 and in further unpublished work) may be of considerable value. In essence our task is to find how successfully one can replace hydrogen-like atomic orbitals by combinations of Gaussian terms, experience having shown beyond all doubt that the former are eminently suitable as basic approximations.

(i) In building up wave functions by linear combination of the members of the complete Gaussian class, it is most advantageous to select the members from *different* Hermite sets. With one electron, for example, the detors reduce to single terms, and for an atomic ($1s$) state there are two extreme types of selection

$$\psi(1s) = \rho_1 \exp(-\alpha r^2) + \rho_2 r^2 \exp(-\alpha r^2) + \ldots \quad (1)$$

where every term is included within one single Hermite set, and

$$\psi(1s) = \rho_1 \exp(-\alpha r^2) + \rho_2 \exp(-2\alpha r^2) + \ldots \quad (2)$$

where every term is chosen from a different set.

As the number of terms is increased, (1) is found to converge extremely slowly towards the true solution; on the other hand, (2) converges rapidly, and even two terms can give quite a fair approximation. The reason for this difference is bound up with the asymptotic behaviour of the exact function in momentum space: for large p, this behaves like $1/p^4$, while all terms of (1) behave like $\exp(-Sp^2)$. By taking terms from *different* Hermite sets, however, it is possible to correct this asymptotic failure relatively easily. Indeed, quite a small number of terms can give an excellent approximation to the exact solution over the significant range of p values (cf. ref. 6).

(ii) It is not generally practicable to make the best possible selection of functions of given type, for too many features are variable. If the number of terms is restricted to two or three, however, one can make this best choice by a rigorous variation treatment. The following results were obtained in this way, using two-term functions in dealing with the $(1s)$ and $(2p)$ states of a hydrogen-like atom. The functions employed were:

$$\text{Momentum space} \begin{cases} \chi(1s) = \exp(-Sp^2) + \mu \exp(-sSp^2) \\ \chi(2p) = \mathbf{c}\cdot\mathbf{p}[\exp(-S\,p^2) + \mu' \exp(-s'S'p^2)] \end{cases}$$

$$\text{Co-ordinate space} \begin{cases} \psi(1s) = \exp(-\alpha r^2) + \rho \exp(-t\alpha r^2) \\ \psi(2p) = \mathbf{c}\cdot\mathbf{r}[\exp(-\alpha\, r^2) + \rho' \exp(-t'\alpha' r^2)] \end{cases}$$

where

$$\alpha = 1/4S,\ \rho = \mu/s^{3/2},\ t = 1/s$$
$$\alpha' = 1/4S',\ \rho = \mu'/s'^{5/2},\ t' = 1/s'.$$

In each case $\mathbf{c}$ is a constant unit vector and the functions are not normalized. Best values of the constants are found to be (using atomic units)

$$s = 6{\cdot}6,\ \mu = 12{\cdot}3,\ S = 0{\cdot}188{,}02/Z^2$$
$$s' = 4{\cdot}6,\ \mu' = 17{\cdot}8,\ S' = 1{\cdot}653{,}5/Z^2,$$

where Z is the nuclear charge. S and μ are thus characteristic of the *type* of function to which we approximate and are conveniently regarded as fixed constants. The one remaining parameter S provides a function of flexibility roughly equivalent to that of the conventional screening-constant wave function. The energy values calculated from these functions are compared below with those obtained using one-term functions.

	1 term	2 term	Error (per cent)
E $(1s)$ (atomic units)	$-0{\cdot}424{,}42\ Z^2$	$-0{\cdot}485{,}82\ Z^2$	2·84
E $(2p)$ (atomic units)	$-0{\cdot}113{,}18\ Z^2$	$-0{\cdot}123{,}24\ Z^2$	1·34

The single-term approximation is obviously very bad in each case; but the removal of 82 per cent and 85 per cent of the respective residual errors by inclusion of a second term is quite remarkable. This is encouraging, but unless subsequent terms are selected with comparable care the rapid convergence is not continued; it is this necessity for careful selection which seems to constitute one of the most serious obstacles to progress.

(iii) Using a limited number of terms, we have made preliminary investigations of He and H_2^+. As expected, only one parameter is sensitive to effective nuclear charge. Rough basic functions of Gaussian type may thus be written down for any problem in terms of the effective nuclear charges of screening constant theory, using the results of (ii) (which may, of course, be extended to include higher states).

Whether further progress will prove possible remains to be seen; our experience suggests that in any particular molecular problem the number of detors necessary is likely to become enormously large.

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[2] McWeeny, Dissertation, Oxford (1948).
[3] Boys, *Proc. Roy. Soc.*, A, **201**, 125 (1950).
[4] Duncanson, *Proc. Camb. Phil. Soc.*, **37**, 397 (1941).
[5] McWeeny and Coulson, *Proc. Phys. Soc.*, A, **52**, 509 (1949).
[6] McWeeny, *Proc. Camb. Phil. Soc.*, **45**, 315 (1949).

TURF AND GREENKEEPING

ST. IVES RESEARCH STATION

THE St. Ives Research Station, at Bingley, Yorkshire, of the Board of Greenkeeping Research may be said to have started its active investigational and advisory work on June 1, 1929, and the twenty-first anniversary of the Station is to be marked by a three-day conference in mid-September, under the chairmanship of Lord Brabazon of Tara. On that occasion the experimental ground will be open, by invitation, to representatives of sports clubs, when there will be demonstrations of turf experiments in progress, an exhibit showing the history and development of the Station and a display of present-day equipment used in turf production.

The credit of suggesting that turf, as distinct from grassland, should form the subject of scientific investigation rightly belongs to the Green Committee of the Royal and Ancient Golf Club of St. Andrews, which, in May 1924, convened a meeting of representatives of golf clubs in Great Britain and Ireland for the purpose of exploring the matter and devising a programme. It was unanimously decided to proceed further by setting up a scientific committee under the chairmanship of the late Sir Robert Greig, then secretary to the Department of Agriculture for Scotland. This committee prepared a scheme of research; but the result of an appeal for financial support was insufficient to warrant a start at that time, and the matter was left in abeyance. In the autumn of 1926, however, the Green Committee of the Royal and Ancient Golf Club approached the British Golf Unions' Joint Advisory Council (a body elected annually by the four national golf unions) and asked if it would take up the question of turf research. The Council agreed, and after careful inquiry, assisted by Sir Robert Greig, a comprehensive scheme was prepared. This involved a guaranteed income for five years, each national golf union being responsible for raising a quota based on the number of courses used by affiliated clubs. The response to this new scheme was wholehearted, and in February 1929 the Board of Greenkeeping Research was set up by resolution of the Joint Advisory Council.

Following this, it was necessary to choose a site, and eventually the St. Ives estate, Bingley, Yorkshire, was chosen, accommodation for laboratories and offices with some five acres of adjacent land being leased. The preparatory work on the new Station began in June 1929, and within a few years the lease was extended to cover additional rooms and an area of land amounting to twenty acres, while the staff grew to some twenty-five in number. These years also saw an awakening of interest in the work of the Station by bowling, cricket, football and other clubs.

The story of the Station really falls into four chapters: the pre-history period (already referred to) during 1924–29 when initial support was being obtained; the period of early growth, 1929–39, when much preliminary investigation was done; the war period, 1939–45, when the activities were maintained on a nucleus basis; and finally the fourth period, 1945–50, during which a full programme of research was restored. This period has been conspicuous by the ever-growing interest and enthusiasm of clubs other than golf which are equally desirous of improving the standard of their turf and benefiting from the results of the scientific work of the Station. Steadily increasing support has been forthcoming from such quarters as football clubs, bowling clubs, general sports clubs, industrial welfare clubs, public authorities, education committees, as well as some of the larger sports associations.

The management of the Station is in the hands of the Board (appointed annually by the Joint Advisory Council), which is supported by a Scientific Advisory Committee as well as a Practical Advisory Committee composed of greenkeepers and groundsmen. The system of quotas from the national golf unions has continued, but with a fifty per cent increase since the War.

At all times during its twenty-one years of existence, development at the Research Station has been restricted by the smallness of the income. Nevertheless, by careful budgeting and modest spending, steady progress has been made, and, although the income rose steadily from £2,140 in 1930, it had only reached a figure of a little more than £10,000 in 1949. The Board has at no time been in receipt of any State grant, but has built up its reputation and assets by means of contributions made to research by sports clubs, associations and other interested persons and bodies. These voluntary contributions have all been at a low level; but, as they confer a right to a postal advisory service, there is a marked tendency for the subscriber to regard his contribution as being paid for direct services and not for research. Consequently, the advisory services tend to overshadow research activities. The income of the Station is not entirely derived from subscriptions, but is supplemented by fees earned by advisory officers carrying out personal visits to sports grounds. The Board is responsible for a volume of work and service not elsewhere available, and the Station is one of the very few receiving no State grant. It is independent and non-profit-making, the members of the management committee receiving no payment for their services.

It may be well at this point to refer briefly to the experimental work. Most of this has been done at Bingley; but outside experiments dealing with specific problems (for example, control of leather jackets) have been done on actual sports grounds and golf courses as occasion demanded. The experimental ground at the Station is laid out in groupings of plots devoted to specific inquiries, primarily applied or practical, and some fifteen hundred turf plots are at present under observation. Many subjects have been investigated during the twenty-one years, but the first experimental plots to be put down in 1929 are still in existence. They comprise single-species sowings and simple mixtures upon which are superimposed comparative manurial treatments. This series has been maintained (on parallel lines to Park Grass, Rothamsted, but under putting-green conditions), without major alterations in management. This long-range experiment has provided much information on the influence of manures on weed and earthworm invasion, upon resiliency of turf, relation of quality to soil reaction, and upon susceptibility to disease. It is clear from this and other experiments that the desirable grasses for dwarf swards (species of *Festuca* and *Agrostis*) do not require high fertility or alkaline soil conditions. Mowing is a factor of major importance in determining species in a turf, since mowing—unlike grazing—is entirely non-selective.

In fine-turf cultivation earthworm activity can be a serious detriment, and much time has been devoted to trials with promising eradicants, with the result that lead arsenate, permanganate of potash and derris have been added to the list. The search for cheaper and more efficient materials continues.

Undoubtedly the most serious problem in turf upkeep is the prevention or eradication of weeds, and throughout the history of the Station work has been devoted to this aspect. Early work was mainly concerned with the influence of ammonium sulphate and other ammonium salts with or without the addition of ferrous sulphate. Later, attention was turned to selective spraying with dilute solutions of arsenic acid. Since the War, however, work has been concentrated on growth-regulating substances. In fact, much of the information available to-day is based on the plot experiments at Bingley. This work has aimed at ascertaining the relative susceptibility of weed species, while optimum rates have been worked out for the sodium and amine salts as well as the esters of M.C.P.A. and D.C.P.A.

So far as insect pests are concerned, perhaps the most serious and widespread is the leather jacket (larvæ of Tipulids), it being quite common to find infestations in the order of 500–1,000 per square yard. Earlier work showed *ortho*dichlorobenzene to be a useful expellent, while later investigations proved the value of lead arsenate. More recently, however, following upon the post-war work of the Station, both DDT and 'Gammexane' have been widely adopted in practice.

Under conditions of high nitrogen fertility combined with a high level of cultivation, mown swards become susceptible to certain fungal diseases, notably *Fusarium* patch. Here again, investigations have provided data on control; but the search for more efficient fungicides continues.

There is a marked tendency among those responsible for turf management to think only in terms of mowing and occasional applications of fertilizer; but pre-war work, more fully substantiated later, has clearly shown the importance of mechanical operations like raking, harrowing and spiking. There is an ever-present tendency where turf is growing under acid soil conditions for the *Agrostis*, in particular, to form a surface mat and for the grass to be short-rooted and of low drought resistance. The penetration of this mat by forking and spiking has been proved to give stronger root development, better moisture

penetration and better drought resistance with more rapid recovery after drought. The findings at the Station on this side of turf upkeep have been largely instrumental in the development of suitable machinery for treating both small and large areas. Indeed, throughout its history the Station has consistently encouraged implement makers to bring prototypes and final models to the Station for trial and constructive criticism. So important is the machinery side considered, whether it be for mowing, aeration or any other purpose, that the Board has set up at the Station a permanent implement exhibition where up-to-date tackle can be suitably displayed, while provision has been made for practical demonstrations.

Several other lines of work remain to be briefly mentioned: first, a study of grass strains, leading to the selection of several improved types of *Agrostis* and fescue, a study of seed establishment and of seed mixtures for various purposes, together with the most practical methods of sowing; secondly, the establishment of new swards from sods; and thirdly, studies on the importance of top-dressing closely mown swards with finely prepared composts and sand. Linked to this there are experiments on bitument treatment of new-sown and established swards.

Most of the lines of investigation briefly outlined above, together with some others, are continuing in one form or another. The aim throughout is to provide information that can be disseminated through the advisory service. It may not be without interest to record that in the past year 942 advisory visits were carried out to sports clubs and golf clubs throughout Great Britain and Ireland (with some on the Continent of Europe), while 8,343 advisory letters were sent through the post. The advice given is supported by soil analyses in the laboratory which, together with past experience and the growing fund of information derived from the experimental work, enable the advisory officers to tender advice at a high level of efficiency.

A feature of the work at the Station has been the development of the educational side. Courses of instruction in the science and practice of turf upkeep are now held at intervals. They cover one week, and groundsmen and greenkeepers receive an intensive course of lectures and practical work. Extension work involves a range from lectures to groundsmen's and greenkeepers' associations throughout Great Britain to the preparation of articles on turf matters and to the issue of the Board's *Journal* each year. There have been twenty-five issues of this, three being since the War.

The Station at the moment is extending, although such growth is at present handicapped by lack of further accommodation; but, if the necessary capital were available, this handicap could be overcome. Future development envisages a continual widening of the advisory service by adding still more clubs to the ever-growing list of subscribers, on which are numbered already many of the foremost cricket, football, bowling and other clubs. It is probable that the demand for courses of instruction in turf upkeep will grow, and the experiment of holding an evening course in the Midlands is to be tried out next winter.

Not only is it likely that a greater measure of support will be forthcoming from individual sports clubs, but also the moral and eventual financial backing of the ruling bodies governing each particular sport may be confidently expected. The provision of development funds would enable the Station to emerge before its silver jubilee as a truly national turf research centre concentrating upon what is undoubtedly the most important asset of the great 'industry of sport'.

HEALTH TEACHING IN THE UNIVERSITY

IN a recent issue of the *Health Education Journal* (8, No. 2; April 1950), Prof. F. C. Thomson, of the School of Public Health, University of Minnesota, describes the courses in health which are being given in the University. Teaching of general courses in health is one of the functions and responsibilities of the School of Public Health, and these have been designed for students who desire some knowledge of personal health and an understanding of the problems of community health. The course in 'personal health' is offered four times during the three terms of the academic year. In several colleges of the University this general course in personal health or an acceptable substitute must be taken before graduation. In certain of the colleges a student may be exempted from this course if he passes an examination prepared by the staff of the School of Public Health; but the number exempted is small. Examples of the topics dealt with during one term are: understanding ourselves as living organisms; certain essentials for health; nutritional needs; safe milk, water and food supplies; digestive disturbances; prevention and care of respiratory disorders; auditory and visual problems; dental health; common skin diseases; protection against communicable diseases; important health problems of the present day (heart disease, cancer, tuberculosis, etc.); accident prevention; endocrines; reproductive system; venereal diseases; health of the mother and child; mental health; alcoholism and narcotic addiction; personal health as a part of community health; facilities for medical care; health agencies.

The introductory course in community health is open to students who have shown that they have an adequate knowledge of personal problems, the general plan being similar to that for the personal health course. The subjects discussed include: origin and growth of the community's interest in health; spread of communicable diseases from man to man; diseases of animals transmitted to man; arthropods and the spread of disease; community programmes in the control of communicable diseases; healthful housing; safe water for rural and urban communities; sewage treatment and refuse disposal; maintaining barriers against food-borne diseases; community problems in mental hygiene; attacking the problem of venereal disease; community programmes in the control of heart disease, cancer, diabetes and tuberculosis; safeguarding maternal and child health; health protection and promotion in the schools; care of handicapped individuals; nutritional deficiencies; health maintenance in industry; community safety programmes; community participation for health education; official tax-supported health agencies; voluntary health agencies; analysing the morbidity and mortality records of a community.

There is evidence that the courses are much appreciated by students and put to practical use in their subsequent careers.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

New Techniques in Autoradiography

THE recent communication of Winteringham[1] has focused attention on the two main difficulties which limit the value of the autoradiographic method in the study of the distribution of soluble radioisotopes of short half-life. These two problems, that of preparing the tissue without loss of the soluble tracer, and the enormous radiation intensities needed for a successful exposure, have been largely solved in our work; and in view of the general usefulness of the methods employed, a preliminary publication of their essential features may not be out of place.

The preparation of the specimens is carried out by the freeze-drying method; the apparatus used is essentially the same in design as that described by Gersh[2]. A central chamber, connected through a phosphorus pentoxide drying-tube to a mercury diffusion pump, is surrounded by a Dewar-insulated cooling jacket. The cooling jacket is itself linked with a second (rotary) vacuum pump so that it can be maintained at any desired pressure below the atmospheric level. Cooling is carried out by the use of liquid methyl chloride, which is available in gas cylinders from any firm of refrigeration engineers. Methyl chloride is perfectly safe for use in an open laboratory; it can be blown from the storage cylinder into an ordinary 'Thermos' flask and poured into the cooling jacket through a tin funnel. Its boiling point is − 20° C. at atmospheric pressure; under about 350 mm. pressure it boils at − 50° C., a temperature which we have found generally useful for the freeze-drying process. One filling of the jacket will suffice for forty-eight hours, by which time drying of a small specimen is usually complete.

Before starting work on a specimen, a layer of molten paraffin wax of suitable melting point is poured into the bottom of the central chamber and, while still liquid, is 'de-gassed' under a few millimetres pressure in the main vacuum line. The wax is then allowed to solidify and the methyl chloride poured into the cooling jacket. The specimens, placed on copper trays, are frozen in *iso*pentane cooled in liquid nitrogen, and are immediately transferred to the drying chamber, which is then evacuated.

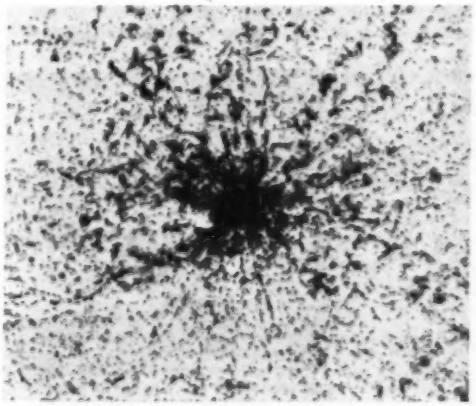

Fig. 1. Track radiograph of a single *Colpidium* fixed from a culture kept 24 hr. in 1 μC./ml. of P^{32}. Ilford *G*.5 emulsion. Many short tracks of low energy obscure the organism. (× 500)

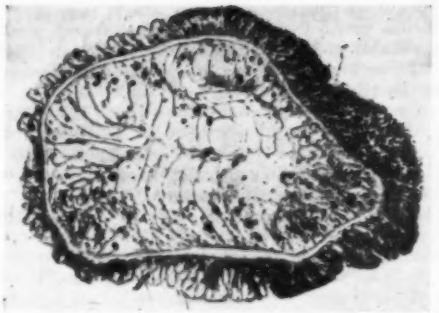

Fig. 2. Transverse section of the base of a tentacle of *Hydra*, fixed by the freeze-drying method, and stained in Hæmatoxylin–Eosin. Note the considerable thickness of the mesoglœa, which is probably the natural condition. (× 100)

When the specimen is dry, infiltration with wax is carried out *in situ*. The residual methyl chloride is pumped out of the cooling jacket and is replaced by commercial ethyl alcohol. An electric heating element (built into the cooling jacket) is switched on, and the pressure in the jacket is reduced by the jacket pump to allow the alcohol to boil at a suitable temperature for melting the wax without overheating. During infiltration, the pressure in the main vacuum line is allowed to rise to an appreciable fraction of the atmospheric pressure, since we have found that lower pressures rapidly volatilize the low-melting point fraction of the wax; if this occurs, its melting point may rise as much as 10–15° C., producing blocks which are brittle and impossible to section.

After embedding, the block is sectioned and the ribbon of sections is flattened on a clean mercury surface at 50° C., sufficient to soften the wax without melting it. (We are indebted to Prof. J. F. Danielli for this suggestion.) A suitable photographic emulsion (on glass) is momentarily pressed on to the floating section, which can be removed perfectly flat and dry.

So short a contact with mercury does not affect the photosensitive properties of the emulsion, which is then 'exposed' to the tracer action for any desired time. If a control section is used for histological comparison, the autoradiograph section is dissolved off with xylol, the plate is run through an aqueous alcohol series and, when in water, is developed and fixed. If it is desired to retain the exposed section intact, a light touch of 1 per cent celloidin in ether–alcohol, applied with a fine camel-hair brush to the dry section, will fix it in place during the subsequent processing.

By the use of electron-sensitive emulsions such as the Kodak *N.T*.4 or Ilford *G*.5, the sensitivity of the autoradiographic method can be increased about ten thousand times as compared with that using ordinary X-ray type emulsions (see also Boyd and Levi[3] for the use of this method with carbon-14). Sections giving a Geiger–Müller β-particle count of only 10 counts/min./sq. mm. of section give autoradiographs of excellent contrast with an exposure of a few hours, and by studying individual tracks instead of photographic density, the emission of as few as four β-tracks from a single *Colpidium* has been recorded with a three-hour exposure. A track radiograph of a more active sample is shown, in Fig. 1, and a section of *Hydra* frozen-dried by the method, in Fig. 2, to illustrate the satisfactory histological preservation achieved.

This work has been largely made possible by a generous grant from the Medical Research Council, and we also wish to thank Messrs. Kodak and Messrs. Ilford for the provision of special emulsions from time to time.

JOHN E. HARRIS
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H. H. Wills Physical Laboratory,
University of Bristol. April 26.

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[2] Gersh, I., *Anat. Rec.*, **53**, 309 (1932).
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Spectroscopy of Cells: the Use of a Reflecting Microscope and Spectrographic Recording

THIS communication describes the use of a simple microspectroscopic method which permits the recording of the ultra-violet and the visible absorption characteristics of cells or portions of cells within a period of a few seconds. The apparatus consists of a light source which emits radiation throughout the ultra-violet and the visible spectrum, a microscope with a reflecting achromatic condenser and objective of numerical aperture 0·56 (designed by Mr. A. J. Kavanagh and made by the Scientific Instrument Division of the American Optical Company), and a small quartz spectrograph (Hilger).

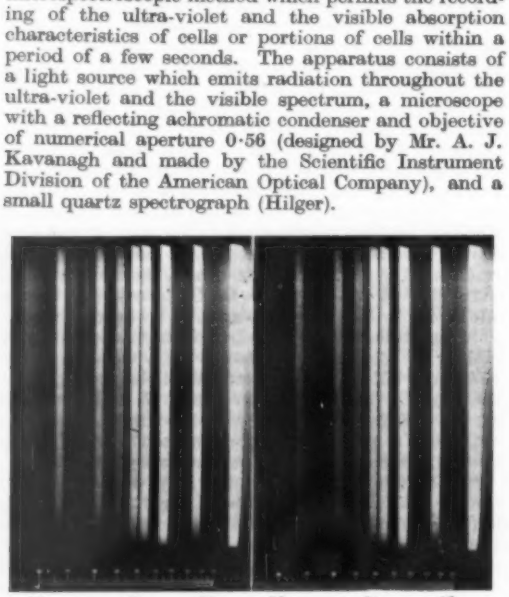

Fig. 1. Reference mercury spectrum (on left) and similar recording (on right) for living cell in tissue culture (chick embryo heart). Wave-length scale in 10 mμ

The principle of the method has been described by Barer[1] and by Barer, Cole and Thompson[2] in their use of the Burch[3] reflecting microscope. An achromatic reflecting condenser focuses the visible and the ultra-violet spectrum of the source on the object. An achromatic reflecting objective forms an image of the object on the slit of the spectrograph. These images are dispersed by the quartz spectrograph and refocused on the photographic plate as a series of discrete or overlapping monochromatic images, of which there exists one for each wave-length of light emitted by the source. For the quantitative estimation of absorption in relation to a reference spectrum and for the detection of finer detail in the spectrum, the photographic plate may be moved during exposure by means of a logarithmic cam in accordance with the method of Holiday[4].

The light sources that are used are the bright line spectrum of the mercury arc (type *AH*-4) in an illuminating system designed by the Research Department, Polaroid Corporation, and the continuous spectrum of the hydrogen arc. The image magnification at the slit of the spectrograph is 50 ×, while at the photographic plate it is 150 ×. The focus at the plane of the slit is made in visible light. The uniformity of the illumination of the slit is determined by densitometric study of the photographic images. The minimum width of the slit which can be used is 0·02 mm., which corresponds to a dimension of 0·4 μ in the object, while the maximum width is 0·3 mm., which corresponds to a dimension of 6 μ in the object.

The recording materials are chosen on the basis of various characteristics: Kodak *SWR* for the far ultra-violet region; Kodak 103–0 *UV* for speed; Kodak Metallographic for general use. The time required for exposure varies from a fraction of a second to sixteen seconds, which is the time for one excursion of the logarithmic cam.

Studies, which will be the subject of future reports, were made of a wide variety of cell-types utilizing various means for their preparation. It is of particular interest that the spectroscopic method is applicable to living cells in tissue culture. In Fig. 1 on the left is a reference mercury spectrum with a logarithmic exposure, while on the right is a similar recording for a portion of a living interphase cell in tissue culture (chick embryo heart). The injurious effect of the ultra-violet radiation was not manifest during the few seconds required for recording the spectra, but became apparent about twenty minutes

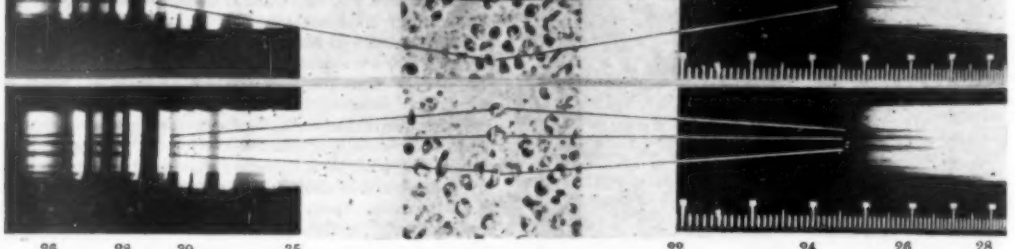

Fig. 2

Cellular absorption spectrum (bright-line source)

Above, smear of lymphocytes of mouse spleen; below, smear of leukæmia cells of mouse spleen. (Photomicrographs by phase microscope)

Cellular absorption spectrum (continuous source)

after the completion of the study. Comparable studies on living cells in mitosis indicate a shorter time-lapse before an injurious effect is seen.

Smears of exfoliated cells, such as those of diagnostic importance in clinical cancer, and smears of bone marrow are nearly ideal material. A series of ultra-violet spectral images of immature leukæmia cells derived from human bone marrow have been analysed in a microdensitometer after appropriate calibration of the plate, and the characteristics of the cell recorded in terms of its spectral absorption along any plane perpendicular to the plate. When the spectrograph is astigmatic as in the present study, there is distortion of the image for which allowance must be made.

Smears, or thinly spread preparations of soft tissues, are suitable material. In Fig. 2 are representative studies of two smears of mouse spleen, one containing normal lymphocytes and the other containing abnormal lymphocytes of leukæmia in the *Akm* strain of mouse (kindly supplied by Dr. J. H. Burchenal). The absorption spectra, when recorded with a continuous source as shown on the right, differ both in the horizontal, or *spectral*, dimension and in the vertical, or *morphological*, dimension.

Tissue sections in general are less satisfactory and are more difficult to prepare. It is necessary either to freeze, cut[5], and dry[6] unfixed tissue in the frozen state, or to use a material for embedding, such as polyethylene glycol[7], which minimizes the loss of cellular constituents in the histological solvents. Thin sections must be used in order to decrease the loss of light by dispersion. Ultra-thin sections[8] may prove to be eminently satisfactory if an embedding procedure can be devised which avoids the use of lipid-solvents.

The spectrographic method described can also be used to study the primary fluorescence spectra of natural components of cells and the secondary fluorescence spectra induced in cells by the localization of fluorochromes. The visible light, or selected portions of the ultra-violet region, emitted by the source is filtered out, and the fluorescence spectra are recorded with a very sensitive panchromatic emulsion.

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Helium II Transfer on Metal Surfaces

ONE of the most striking features of the film flow in liquid helium II is provided by the fact that the rate of transfer seems to be largely independent of the experimental conditions[1]. It was thought for some time that the rate was influenced by the geometrical shape of the transfer vessel, or by a temperature gradient in the film[2], or by small amounts of thermal radiation[3]. However, recent experiments by R. Bowers and one of us[4] have demonstrated that the real cause for these changes in the transfer-rate was a contamination of the solid surface over which the transfer took place with a thin layer of solid air. It was also found that contamination with solid hydrogen and solid neon produced similar effects.

These observations directed attention to the nature of the transfer surface and in particular to the influence of thin adsorbed layers of a second substance. Practically all quantitative observations of the transfer-rate have been made on glass surfaces. It was noted in the early experiments of Daunt and Mendelssohn[1] that scraped copper wires yielded a higher transfer-rate; but subsequent experiments with a polished copper beaker showed the same rate as on glass. Nevertheless, it has to be borne in mind that all these surfaces had been exposed to air and water vapour before examination, and this might have influenced their transport properties. In view of the recent results of Bowers and Mendelssohn, a re-examination of the problem with uncontaminated surfaces seemed, therefore, indicated.

The experiments were carried out in a small Linde helium liquefier[5], and provision was made for degassing the transfer surfaces thoroughly before the observation. The conventional type of beaker was used which, however, could be heated first *inside* the apparatus if necessary to about 600° C. After de-gassing, the solid surface was only exposed to the very pure helium gas employed in the liquefaction process. Platinum and nickel were used, the former because it was certain to be free from an oxide layer. Cylindrical metal beakers were suspended in a narrow vertical glass tube which was partly filled with liquid helium II, and the rate at which the liquid-level changed in the annular space between metal and glass was observed. The character of the film transfer was identical with the earlier observations, being in first approximation independent of the level difference and of the length of the path traversed. The dependence of the rate on temperature, too, was roughly similar to that on clean glass beakers; but the absolute value of the flow was considerably higher. On the other hand, a glass beaker used in the same arrangement yielded the same rates as all the earlier experiments. A short summary of the results is given in the accompanying table.

TRANSFER RATES OF HELIUM II OVER DIFFERENT SURFACES
(10^{-5} CM.^{3}/CM./SEC.)

T ° K.	Pt cleaned	Pt cleaned and baked	Pt polished and baked	Ni cleaned and baked	Glass cleaned
1·2	15·9	21·4	22·4	24·3	7·3
1·5	16·9	20·8	21·0	22·7	7·1
1·8	13·0	16·5	17·0	17·0	6·2
2·0	6·9	8·8	9·9	9·5	3·8

These observations appear to leave no doubt that the nature of the underlying surface will influence the transfer-rate through the film. However, although

a considerably higher rate has been observed on clean platinum and nickel than on clean glass, it is clearly too early to say whether this effect is due to the different type of interatomic forces or to more macroscopic features of the surfaces. A more detailed description of the work will be published in the near future.

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The D—D Reaction as a Standard Neutron Source

THE first of the two possible D—D reactions

$$D_1^2 + D_1^2 \rightarrow He^3 + n$$
$$\rightarrow H^3 + H^1$$

has long been used as a source of mono-energetic neutrons. To use it as a standard source of neutrons requires either the counting of all the neutrons, using, for example, a water-tank method, or the counting of the helium-3 particles, which is difficult because of their very short range. But if, with given conditions, the ratio of the number of helium-3 particles to the number of hydrogen-3 or hydrogen-1 particles from the second reaction is once found, then the neutron flux may afterwards be determined merely by counting the number of hydrogen particles, which is much easier owing to their greater range.

Experiments were performed to find this ratio using a copper block as a target. The block was bombarded with a deuteron beam accelerated from a radio-frequency ion source using a voltage-multiplying circuit. With a 100-μ amp. beam, a counting-rate of 1,000 per minute was observed in a solid angle of $4\pi \times 10^{-4}$ radians from the deuterium driven into the target.

The counting of the helium-3 particles was made possible by the use of the thin silica windows of thickness equivalent to 0·2 mgm./cm.^{2} of air, described by Thonemann[1]. The charged particles emitted at 90° to the beam passed through this window into the first of two proportional counters. At a pressure of 11 cm. of mercury (10 : 1 argon – alcohol mixture) the helium-3, hydrogen-3 and hydrogen-1 nuclei gave pulses of relative magnitude 12 : 4 : 1 respectively. By using a pulse-amplitude selector, the helium-3 and hydrogen-3 peaks could be completely separated, and the incomplete separation of the hydrogen-3 and hydrogen-1 peaks would not introduce errors exceeding 1 per cent.

The second counter was isolated from the first by means of an aluminium window (thickness 4 mgm./cm.^{2}) sufficiently thick to stop the helium-3 and hydrogen-3 nuclei. The protons counted in this were used to monitor the beam, and the equality (within the statistical error) of the proton and triton counts in the two chambers when two side-on counters were used served as a check on the accuracy of the experiment. This equality is demonstrated by the following figures :

Energy in keV.	80	110	140	160
Ratio H^2/H^1	1·01 ± 0·04	0·95 ± 0·06	1·01 ± 0·03	1·02 ± 0·03

Three different sets of experiments using different counters, and in one case an aluminium instead of a copper target, gave consistent results.

The ratios of the number of helium-3 particles to the number of hydrogen-3 particles at different incident beam energies were found to be :

Energy in keV.	70	80	90	100	110	120
He^3/H^3	0·86	0·89	0·906	0·92	0·926	0·96
Standard statistical error	±0·02	0·03	0·01	0·01	0·01	0·03

Energy in keV.	140	160
He^3/H^3	1·00	1·02
Standard statistical error	±0·01	0·03

As the distribution of deuterium in the target is not known, absolute cross-sections cannot be obtained using this type of target. Preliminary runs with a gas target at 120–160 kV. do not show any significant deviation from the above results.

We wish to express our thanks for the help given by Dr. D. Roaf and the other members of the High-Tension Group.

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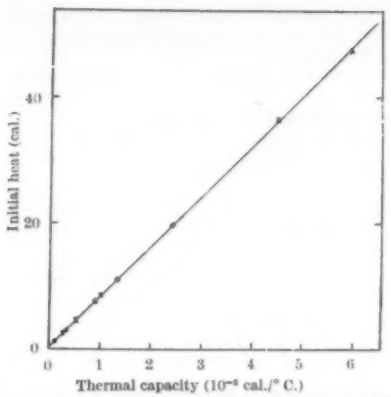
Mechanism of Ignition by Local Sources of Heat

THE conditions under which combustible materials may be ignited by contact with hot bodies have been the subject of intensive investigations, mainly with the object of determining the minimum temperature of the body necessary for ignition. Experiments have recently been reported by Jones[1] in which the energy necessary to ignite certain deflagrating solids by means of a hot wire embedded in them was measured, the wire being heated by means of an electric current maintained for a limited time. The experiments showed that a definite amount of energy must be supplied to the wire for ignition to result, this quantity decreasing as the rate of supply increases, but still remaining finite even when the rate of supply is infinite, corresponding to the instantaneous generation of heat in the wire.

The use of wires of different materials indicated that under conditions where it was supplied instantaneously, the energy necessary for ignition consisted of two parts, one part being transferred to the solid and the other part remaining in the wire. Over the range of diameters considered, 1×10^{-3} cm. to 5×10^{-3} cm., the energy transferred to the solid was constant, but that remaining in the wire was proportional to the thermal capacity and equivalent, therefore, to a constant temperature of wire at ignition. The critical energy transferred to the solid, and the temperature of the wire at ignition, are dependent on the nature of the solid but independent of diameter over the above range.

The mechanism of the ignition process suggested by these experiments is that if a certain quantity of heat is generated in the wire instantaneously, thereby raising its temperature to some high value, ignition will occur when a definite quantity of this heat has been transferred to the surrounding medium, provided



Initial heat in sphere versus thermal capacity, from Silver's data for a 20 per cent hydrogen – air mixture; × – × –, platinum spheres; ○ – ○ –, quartz spheres

that the loss of heat does not reduce the temperature of the wire below a certain critical value.

Experiments carried out by Stout and Jones[2] have shown that similar conclusions may be drawn regarding the ignition of explosive gas mixtures by heated wires, and that again, when heat is generated in the wire instantaneously, ignition will occur provided a certain minimum quantity of heat is transferred to the gas, the temperature of the wire being greater than a certain critical value during the whole time required for the transfer.

The above conclusions refer to cylindrical sources of heat, and it is interesting to examine from this point of view experiments carried out by Silver[3] and Paterson[4]. These authors projected heated spheres into explosive gas mixtures and measured the lowest temperature at which ignition occurred. Platinum and quartz spheres were used, of varying diameter, and it was found that for a given velocity of projection the smaller the diameter of the sphere the higher the temperature required for ignition. In the light of the experiments with the wires, it would be expected that the thermal capacity of the sphere is the important factor, and the graph shows the initial heat contained in the spheres plotted against the thermal capacity, using Silver's data for 20 per cent hydrogen – air mixture. The heat in the sphere increases linearly with the thermal capacity, and the intercept at zero thermal capacity is about 0·4 cal. The slope of the line corresponds to a temperature of 792° C., which represents the temperature of the sphere when ignition occurs. Platinum and quartz behave similarly in spite of great differences in specific heat and density, and it will be found that equivalent results are obtained for the other gases studied by Silver and Paterson.

The hot sphere shot into the gas is analogous to the wire with heat generated instantaneously, and it is clear that exactly the same conclusions apply. The only difference lies in the magnitude of the critical quantities, for whereas the graph shows that the heat lost to the gas by the sphere is 0·4 cal. and the temperature 792° C., the corresponding results for ignition of a 20 per cent hydrogen – air mixture by a wire[2] are about 6×10^{-4} cal. per cm. and a temperature of 2,000° C. Expressing the heat losses in relation to the area of hot surface, these become about 0·04 cal. per sq. cm. for the wires and about 1 cal. per sq. cm. for the spheres. The latter quantity will depend to some extent on the velocity of the spheres in the gas[4]; but there seems no doubt that ignition may be effected either by a small quantity of heat supplied at a high temperature, or by a larger quantity of heat supplied at a lower temperature. The precise conditions will depend on the thermal capacity of the source, for that of the spheres averaged about 10^{-2} cal./° C. whereas that of the wires averaged only 10^{-6} cal./° C. The spheres could therefore withstand a much greater loss of heat than the wires without their temperature falling too low.

When heat is supplied to the source slowly, as with the wires, although similar conditions are necessary for ignition to occur, there is no reason for supposing that the temperature of the wire at ignition is the same irrespective of the rate of heating. The very fact that the energy required is greater the slower the rate of heating is sufficient indication that the temperature of the wire is reduced under these conditions.

It must be emphasized that the experiments discussed provide information solely concerning the division of the critical ignition energy between source and medium. Any conclusions drawn regarding the detailed thermal conditions existing in the medium at the moment of ignition must be regarded as purely conjectural.

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Low-Frequency Dielectric Absorption in Organic Long-Chain Compounds due to the Presence of Traces of Alcohol Impurities

IN recent investigations of the electrical properties of crystalline long-chain ketones and esters[1], considerable dielectric absorption has sometimes been observed at low audio-frequencies. This absorption appears to have electrical characteristics similar in all respects to the well-known low-frequency absorption which is usually attributed to ionic impurities or structural discontinuities, or a combination of the two (see, for example, ref. 2). The above measurements are now being extended to frequencies as low as 0·5 c./s., using a Schering bridge with a Lindemann electrometer as detector. The bridge is supplied with alternating potentials from a motor-driven sine–cosine potentiometer and 135-volt dry battery. Mercury electrodes with a clamped steel guard-ring are used, the electrode system being similar to, but smaller than, the one described by the Electrical Research Association[3]. Measurements of anomalous charging currents following the sudden application of a steady D.C. voltage are also being made, using the Lindemann electrometer in the way described by Doust and Sulston[4]. When possible, the steady-state D.C. conductivity (σdc) has also been obtained from the same readings.

In general, it is found that the dielectric loss factor continues to increase with decreasing frequency in this region. In the course of these experiments it was observed that the highest losses were associated with materials which had been purified by vacuum

distillation. Subsequent recrystallization of such materials from a solvent led to a considerable reduction in the loss factor, accompanied by an even larger decrease in the D.C. conductivity. The following results were obtained, at about 15° C., with the long-chain ketone, palmitone:

	σ D.C. ($\times 10^{-12}$ mho-cm.$^{-1}$)	Dielectric loss factor at 3·9 c./s.	1·3 c./s.	0·44 c./s.
Vacuum-distilled	8	0·10	0·22	0·41
Recryst. from alcohol	0·1	0·002	0·004	0·005

Since the vacuum fractionation of these compounds involved heating at high temperatures in a restricted supply of oxygen, it seemed probable that the observed effect on the electrical properties was related to the presence of oxidation products in the material. In support of this, the ketone laurone gave the following results, before and after heating for two hours at 100° C., with restricted access to the atmosphere:

	σ D.C. ($\times 10^{-12}$ mho-cm.$^{-1}$)	Dielectric loss factor at 3·9 c./s.	1·3 c./s.	0·44 c./s.
Before heating	<0·05	0·002	0·002	0·003
After heating	1·5	0·068	0·12	0·21

Paraffin wax was more stable and required heating for two hours at 330° to give an increase similar to that shown above for laurone.

The autoxidation of long-chain compounds is known to proceed through the formation of hydroperoxides which are unstable and decompose to give alcohols, ketones, acids and aldehydes (see, for example, ref. 5). To determine whether any of these impurities are responsible for the dielectric absorption and high conductivity of oxidized long-chain compounds, electrical measurements were made with paraffin wax to which small proportions of compounds of the above-mentioned types had been added. The addition of 1 per cent of methyl hexyl ketone, *n*-heptaldehyde or caprylic acid gave comparatively little change; but a large effect was obtained with *n*-octyl alcohol ($C_8H_{18}O$), as shown by the following results:

Paraffin wax	σ D.C. ($\times 10^{-12}$ mho-cm.$^{-1}$)	Dielectric loss factor at 3·9 c./s.
1. Untreated	<0·004	0·000
2. + 1 per cent of *n*-octyl alcohol	4000	4·0

Large increases in D.C. conductivity and dielectric loss factor also resulted from 1 per cent additions of *n*-hexyl, *n*-heptyl and secondary octyl alcohols; but cetyl alcohol ($C_{16}H_{34}O$) produced only a small change.

It thus seems probable that the high dielectric absorption at low frequencies and high D.C. conductivity observed with oxidized long-chain compounds are due to the presence of small proportions of alcohols of comparatively short chain-length. The alcohol molecules may be adsorbed at crystal interfaces in such a manner as to enable the formation of hydrogen-bonded chains of hydroxyl groups, which have previously been suggested as a cause of high dielectric absorption in solid secondary alcohols at low frequencies[6].

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Fundamental Lengths and Masses of Fundamental Particles

Certain considerations based on the principles of quantum mechanics lead to the view that the process of localization of a particle in space and time is subject to quantization. Thus if the world line of a particle of rest mass m_0 is considered, it has no physical meaning to subdivide it into elements of length less than h/m_0c, or, what is the same thing, to associate with the particle intervals of proper time less than h/m_0c^2 [1]. This has been expressed as a principle of elementary indeterminacy by Ruark[2] and by Fürth[3].

In the case of the proton, of rest mass M_0, the length h/M_0c might be regarded as the fundamental length of the order of 10^{-13} cm., which has come to be described as the range of nuclear forces. In a recent paper, Fürth[4] has identified this length with Yukawa's expression $h/2\pi\mu_0c$ for this range, μ_0 denoting the mass of the π-meson associated with the nuclear field.

The range of nuclear forces might also be identified with the expression ke^2/m_0c^2, where m_0 is the rest mass of the electron. Unlike the other expressions, this contains a numerical constant k which is not well defined theoretically. Such values as $\frac{1}{2}$ and $\frac{2}{3}$ have been ascribed to it in the classical theory of the electron, and Fürth[5] by a rather different consideration deduced the value 15/32. The constant is evidently of fundamental importance, and if ke^2/m_0c^2 is regarded as a fundamental unit of length, it ought to be derived without any considerations of electron structure or charge distribution. The identification with the other expressions for the range of nuclear forces makes it possible to deduce the value of k_0 with a high degree of accuracy.

Thus, making use of recent data[6], $2\pi e^2/hc = 7{\cdot}2978 \times 10^{-3}$, $M_0/m_0 = 1836{\cdot}57$ (with a certain margin of error), the relation $h/M_0c = ke^2/m_0c^2$ gives $k = 0{\cdot}4688$. Fürth's value, namely, $15/32 = 0{\cdot}46875$, is in remarkable agreement with this.

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Magnetism and the Rotation of Celestial Bodies

In a recent letter, H. P. Berlage[1] has ingeniously attempted to use the idea of a radial separation of electric charge, associated with degenerate matter in the interior of rotating celestial bodies, in order to derive Blackett's formula[2], which seeks to connect the angular momentum of such a body with its magnetic moment.

One can show that, in order to account for the main magnetic field of the *earth*, Berlage's model requires that some 10^6 or more electrons/cm.^{3}, from an appreciable part of the earth's core, would need an energy of the order of 10^{17} volts, in order to produce the necessary migration and separation of charge; as a result, there would have to exist an electric field of 10^9 or more volts/cm. at the boundary of the core.

Since the earth's core is rather widely thought to be metallic, for one reason or another, it is appropriate to examine the possibility that an appreciable separation of electric charge may occur in a conductor subjected to the high pressure and temperature of the earth's deep interior.

Pressure acting alone could cause a charge separation of the proper sign; but, as has recently been pointed out[3], the effect to be expected is very small. Temperature, acting with pressure, does not seem to help appreciably, as can be seen by considering the Fermi–Dirac distribution of the conducting electrons in a compressed conductor at high temperature. The number of electrons per cm.^{3} per unit of energy may be written

$$\rho_E = \frac{\nu\sqrt{E}}{1 + \exp\left(\frac{E - E_m}{kT}\right)},$$

where E is the energy of the conducting electrons, $\nu = \frac{4\pi}{h^3}(2m)^{3/2}$ and, closely enough, $E_m = \frac{h^2}{2m}\left(\frac{3n}{8\pi}\right)^{2/3}$, in which h is Planck's constant, m is the effective mass of the electron, T is the absolute temperature, k is Boltzmann's constant and n is the number of conducting electrons per cubic centimetre. E_m is the maximum energy of the conducting electrons at 0° K.

First consider the effect of compression alone. Taking convenient round numbers, assume E_m to be 10 volts before compression, and that the pressure deep in the earth increases the density there by a factor of 8. (This is an assumption favourable to the theory; actually, it is unlikely that so large a compression could occur.) If m and n remain constant during compression, the maximum energy of the electrons after compression, E_m', is 40 volts. We are probably not justified in treating m and n as constants during so great a compression; but this assumption cannot introduce an error large enough to alter the conclusions that follow below.

Secondly, let us take into account the effect of temperature, assuming T to be 10,000° K. (The temperature deep inside the earth is quite uncertain, but a rough value will do for these calculations; 10,000° K. is not unreasonable.) On carrying this out, we find that ρ_E is a maximum when E is about 36 electron volts. Owing to the relatively small effect of temperature, ρ_E decreases rapidly with increasing E. As a result, we find, for example, that for $E = 85$ volts, ρ_E is about 1 electron per cm.^{3} per electron volt. In other words, there is only about one electron per cubic centimetre having an energy as high as 85 volts, where we should like to find some 10^9 or more electrons having energies of the order of 10^{17} volts.

Thus, for an earth with a conducting core, the difference between the predictions based on the Fermi–Dirac statistics, and the requirements of the charge-separation theory, are so great that it is hard to see how terrestrial magnetism can be due to any appreciable extent to this effect.

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Origin of Sunspots

Although astronomers have commonly believed that sunspots are deep-seated vortices, the chief characteristics of a spot (an intense magnetic field and a cool umbra) have never been successfully explained.

I wish to suggest a new theory of spot origin. One basic assumption is that the sun possesses a general magnetic field, the polar intensity of which is probably only several gauss, from ten or twenty times less than the value usually quoted. The form of the solar corona, which strongly suggests the lines of force emanating from a magnetized sphere, justifies the assumption.

If an ionized and highly conducting gas moves with velocity v in the presence of a magnetic field H, an electric field E results:

$$E = \frac{1}{c} v \times H. \qquad (1)$$

Taking the curl of this equation, and employing the Maxwell equations, we find that

$$\frac{dH}{dt} = H \cdot \nabla v - H \nabla \cdot v. \qquad (2)$$

Introducing the equation of continuity, we finally get:

$$\frac{d}{dt}\frac{H}{\rho} = \frac{H}{\rho} \cdot \nabla v, \qquad (3)$$

where ρ is the matter density of the ionized gas. Equations (2) and (3) show that the lines of force move with the material and that changes of gas intensity generally imply changes in intensity of magnetic field.

Clouds of ionized gas, ejected from the solar poles in 'spicule activity', can cascade back to the solar surface near the equator. The influx of gases can produce, in accord with (3), a marked intensification of the magnetic field.

An examination of generalized hydrodynamic equations shows that the ionized gas will collapse when the gravitational acceleration exceeds the buoyancy effect of the magnetic field. The general characteristics of many varieties of prominences can thus be explained. Sunspots may result from complete collapse of the field down to the solar surface. The downfalling material will generally flow out away

from the magnetic cores and thus produce cooling. The details of this theory will be given in a later paper.

I wish to acknowledge the help, advice and encouragement given to me by various colleagues, in particular Walter O. Roberts, John W. Evans, Edward Teller, Julian Schwinger, J. H. Van Vleck and M. S. Vallarta.

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Biological Assay of Small Quantities of Desoxycorticosterone Acetate

ALTHOUGH early studies on the adrenalectomized dog[1] have led to means of assay for desoxycorticosterone acetate and for extracts of the adrenal cortex in quantity[2–4], no satisfactory micro-assay has hitherto been described.

In the course of other experiments, methods were developed whereby accurately measured volumes of fluid could be administered to small animals[5]. This technique has been used to give precise salt and water loads to large adrenalectomized mice, with and without injections of desoxycorticosterone acetate. The subsequent rates of sodium excretion have been shown to be related quantitatively to the amounts of desoxycorticosterone acetate injected, over the narrow range of 1·5–12 micrograms per 100 gm. body-weight.

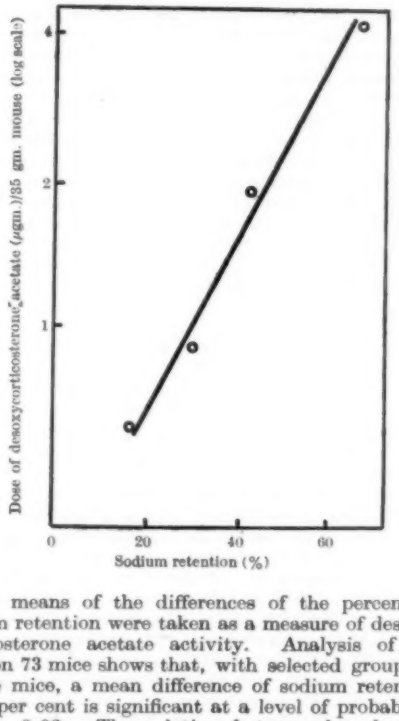
Male Swiss mice weighing 35 gm. were bilaterally adrenalectomized and used for testing from the fourth to the seventh post-operative days. They were fed a standard Rockland mouse diet, with 1 per cent sodium chloride and 5 per cent glucose to drink. To avoid fæcal contamination of urine during test periods, the mice were kept fasting for eight hours before each assay. During this time, 10 per cent glucose water, without salt, replaced the glucose-saline drink. This was to prevent hypoglycæmic attacks, which were otherwise common in fasting adrenalectomized mice, and to ensure that all the animals had no sodium intake before the assay.

Preliminary tests on groups of eighteen mice allowed twelve to be selected which would excrete 70–130 per cent of the sodium load within a period of six hours. At the beginning of the test, the mice were picked up and the bladders were emptied either spontaneously, or by gentle suprapubic pressure. Each mouse was then in turn injected subcutaneously with 2 ml. of the load solution, warmed to 40° C. This solution contained: sodium 138, potassium 4, calcium 3 m.equiv./litre, chloride 128, phosphate 11, bicarbonate 6 m.equiv./litre, and glucose 1 per cent.

The injection apparatus was an all-glass 10-ml. syringe, with a 1½-in. No. 26 S.W.G. needle, fixed horizontally in a clamp, and with delivery controlled and measured by a micrometer screw gauge acting on the piston. Each mouse, held gently in a gauze bag, was brought up to the apparatus and the needle inserted near the tail and carefully slid under the skin to the neck. The injection of 2 ml. was then slowly and evenly distributed around the shoulders. In this manner all the fluid was injected at low tension and distant from the needle puncture, so that none leaked out afterwards.

After injection, each mouse was placed in a one-litre beaker, with wide-gauge wire-mesh platform and lid, and kept in the laboratory at 25 ± 3° C. Six hours later the mice were removed, after emptying their bladders into the beakers. These were then rinsed four times with 20 ml. of distilled water, and the washings made to volume for the estimation of sodium by indirect flame photometry[6].

On the next day, the twelve selected mice, prepared and injected as before, were divided into three groups. The first were injected intraperitoneally with a control solution of 0·2 ml. of 5 per cent glucose, the second with the same solution containing ¼–4 μgm. of desoxycorticosterone acetate, and the third containing the substance to be tested for mineral hormone activity. After six hours the excretion of sodium was measured as previously described. On each subsequent day the groups of mice were changed and the assay repeated until all the mice had in turn acted as control, standard and unknown test animals. This cross-over test minimizes errors due to individual response variation, and to any influence of one test phase on the next.



The means of the differences of the percentage sodium retention were taken as a measure of desoxycorticosterone acetate activity. Analysis of 234 tests on 73 mice shows that, with selected groups of twelve mice, a mean difference of sodium retention of 15 per cent is significant at a level of probability of $P = 0{\cdot}02$. The relation between log dose of desoxycorticosterone acetate and the percentage sodium retention is shown in the accompanying graph. The standard error of the ratio of the potencies[7] may be calculated from the slopes of regression lines[8] for both standards and unknowns.

Blood sample	Sodium retention activity expressed as desoxycorticosterone acetate equivalent
Adrenal vein blood (dog)	4 μgm. desoxycorticosterone acetate per ml. serum
Carotid artery blood (dog)	No activity detected
Human blood obtained by catheter from inferior vena cava at level of 12th thoracic vertebra	No activity detected
Extract from 120 ml. serum from carotid artery blood of the dog	0·04 μgm. desoxycorticosterone per ml. serum

This method of assay has been applied to blood from various sources, with the results shown in the table.

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Direct Oxidation of Glucose-6-Phosphate by Animal Tissues

YEAST[1–4] and red blood cells[5] contain enzyme systems which require coenzyme II and are capable of oxidizing glucose-6-phosphate to 6-phosphogluconic acid. The oxidation can also proceed further[1,3,6], and evidence has been presented that in yeast stepwise C_1- and C_2-oxidation and decarboxylation may proceed via a pentose phosphoric ester; this was considered to be D-ribose-5-phosphate rather than D-arabinose-5-phosphate, which, although it has the configuration of D-glucose, is not attacked by yeast enzymes[6]. Further support for this view has recently been provided by the chromatographic identification of 2-ketogluconate and D-ribose-5-phosphate among the oxidation products of 6-phosphogluconic acid[7].

These oxidative paths in animal tissues have not hitherto received detailed study[3,6,8]; but the preliminary experiments now reported show clearly that similar enzyme systems are, in fact, highly active, sufficiently so to make it possible that they may constitute a main route of carbohydrate oxidation, in some animal tissues.

The tissues were homogenized in 0·01 *M* phosphate of *p*H 7·0 and the inactive precipitates formed by adjusting the supernatant fluid to *p*H 4·6 and 7·0 discarded. Dehydrogenase activity was tested by the rate of reduction of Brilliant Cresyl Blue using Friedemann and Hollander's method[9], and in the dialysed fractions described below by the method of Haas[10]; oxygen uptake was studied as described by Dickens[6]. Active coenzyme II - linked systems for the oxidation of glucose-6-phosphate and 6-phosphogluconic acid are present in extracts of liver, brain and kidney of rat and rabbit and in liver-carcinoma of the rat. These activities are not due to adventitious blood. Extracts of rat and rabbit skeletal muscle and fowl sarcoma No. 1 show relatively feeble activity.

By fractional precipitation of rat liver extracts with ammonium sulphate and subsequent dialysis, partial separation of coenzyme-free dehydrogenases has been effected. The crude fraction, between 30 and 60 per cent saturation with ammonium sulphate, contains glucose dehydrogenase[11] and the dehydrogenases for glucose-6-phosphate and 6-phosphogluconic acid. The percentage saturations for maximum activity of these three dehydrogenases are, respectively, 30–40, 40–50 and 50–60. The last fraction is completely free from glucose-6-phosphate dehydrogenase, showing that these two phosphorylated substrates require distinct dehydrogenases. Oxidation of both glucose-6-phosphate and 6-phosphogluconic acid is specific for coenzyme II and occurs aerobically in presence of a suitable carrier, such as phenazine methosulphate[6], without added flavoprotein. Since glucose dehydrogenase requires coenzyme I and added diaphorase, it could not account for the activity towards glucose-6-phosphate. Moreover, no glucose-6-phosphatase is present in these fractions.

The substrate specificity is high. In the presence of coenzyme II, the 50–60 per cent saturation fraction, though highly active towards 6-phosphogluconic acid, does not oxidize Embden ester, glucose 6-phosphate, gluconic acid, 2-ketogluconic acid, glucose or ribose. The whole system (fraction between 30–60 per cent saturation) vigorously oxidizes glucose-6-phosphate, 6-phosphogluconic acid and D-ribose-5-phosphate (natural or synthetic). It shows slight activity towards D-arabinose-5-phosphate and xylose-5-phosphate, and also towards glycogen and glucose-1-phosphate, the crude syrup presumably containing some phosphorylase and phosphoglucomutase. Gluconic and 2-ketogluconic acids and ribose are scarcely oxidized.

The Michaelis constants for the glucose-6-phosphate and 6-phosphogluconic acid dehydrogenases are 5×10^{-5} *M* and $1{\cdot}7 \times 10^{-5}$ *M*, respectively. The oxygen taken up by 6-phosphogluconic acid and D-ribose-5-phosphate exceeds the molar ratio of unity corresponding to the formation of ketopentonic acid. The facts that neither the oxidation of glucose-6-phosphate nor that of 6-phosphogluconic acid is inhibited by 0·01 *M* sodium fluoride, and that inorganic phosphate is not essential, show that the Embden–Meyerhof glycolytic pathway is not involved.

The relative importance of this direct oxidative pathway and of the conventionally accepted route via the glycolytic intermediates is being investigated in adult and proliferating animal tissues. The direct oxidative route may have a dual function, in carbohydrate oxidation and in the provision of ribose-5-phosphate for synthesis of nucleotides and nucleic acids.

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Birefringence of Amylose and Amylopectin in Whole Structural Starches

THE view is current that unbranched amylose chains are responsible for the anisotropy of structural and fractionated starches[1-3]. (A review of this subject by S. Peat[4] should be consulted.) This view has been influenced by the method of investigation employed. Thus the evidence from X-ray powder diagrams does not entirely coincide with that from the study of optical birefringence. Perfectly dry starches are stated[5,6] to show an amorphous powder diagram though they still exhibit birefringence. The kind of product also matters. Thus, fractionated amylose may be deposited in a micro-crystalline form[4], whereas amylopectin remains amorphous or statistically isotropic. But fractionation procedures may also determine physical states, so that no direct conclusion can be drawn concerning the anisotropy of amylopectin in raw structural starches. Thirdly, interpretation may also be prejudiced by theoretical assumptions regarding the structure of the branched high polymer. Thus the random branching postulated by Meyer[1] would offer a resistance to crystallization absent from the models proposed by Staudinger[7] or Haworth[8].

We now report further evidence relating to these problems. Wrinkled pea, smooth pea, normal maize, waxy maize, and tobacco leaf starches were examined in polarized light. Wrinkled pea starch contains 98 per cent amylose and 2 per cent amylopectin[9]; smooth pea contains amylose and amylopectin in the ratio of 30 per cent to 66 per cent[9]; waxy maize contains amylopectin but no amylose[10]; normal maize contains amylose and amylopectin in the ratio of 21 per cent to 79 per cent[10]. Current investigations at the University College of North Wales, Bangor, show that the ratio of amylose and amylopectin in tobacco leaf starch is approximately 22 per cent to 78 per cent. Our sample of waxy maize starch was obtained from a strain of known genetic purity. We found that the birefringence of waxy maize was not distinguishable in intensity from that of normal maize; that the birefringence of the majority of the aggregate granules of wrinkled pea was conspicuously less than that of the semi-aggregate granules of smooth pea, although wrinkled pea starch always contained, as well as aggregate granules, a smaller number of semi-aggregate granules showing intense birefringence; and, in agreement with Holden and Tracey[11], that leaf starch possessed only minimal though definite birefringence.

These results show, first, that amylopectin in the raw starch granule possesses a crystallite structure, and that the intensity of birefringence bears no obvious relation to the amylose – amylopectin ratio of the granule. It is more plausible, therefore, to attribute the observed variations in birefringence to differences in degree of crystallite orientation rather than to differences in the degree of branching and relative proportions of their component polysaccharides. It was noteworthy that photosynthesized starch, which is deposited and mobilized with exceptional rapidity and in which, therefore, sufficient time may be lacking for full crystallite orientation, showed the least birefringence of the starches examined. The low birefringence of wrinkled pea starch may be due to a similar cause, since Winton[12] states: "The character of the starch grains in immature smooth peas is much like that in mature wrinkled peas. This suggests that the wrinkled pea, although fertile, is either gathered when immature or is incapable of reaching the same degree of development as the smooth variety." Moreover, rapidity of mobilization rather than degree of branching may be responsible for the absence of birefringence from the glycogen in mammalian tissues. In this connexion the little-studied polysaccharide complexes of the Protozoa deserve further investigation. For example, in the oligotrich ciliates of the rumen, iodine-reacting substances are deposited both in an amorphous form and as birefringent structures[13], the so-called skeletal plates. Westphal[14] claimed that both components are glycogen. If this were substantiated, it would show that glycogen as well as amylopectin can exist in a crystalline state.

We wish to acknowledge our indebtedness to Mr. N. W. Pirie, of Rothamsted Experimental Station, for supplying us with leaf starch and for advice on several technical points.

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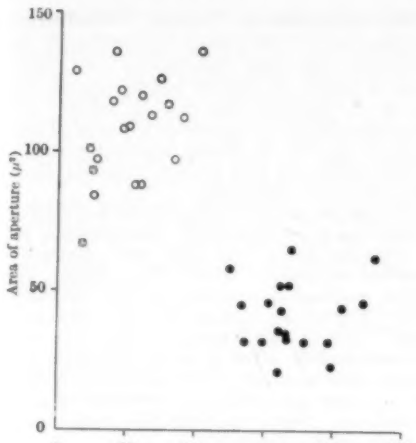
Quantitative Estimation of Stomatal Starch

THE investigations of Heath[1,2] have shown that the classical theory of the control of stomatal movement by starch–sugar balance in the guard-cells must be viewed with the deepest suspicion, at least so far as the light response is concerned; but the difficulty in all such investigations has been the great variation in starch content between different stomata on the same leaf, and the absence of any satisfactory method whereby it could be measured. Neither the method adopted by Heath[2] (the publication of selected photographic records) nor the subjective visual 'scoring' method of Small[3] affords more than a rough survey of a large number of stomata; what is required is a method of estimation of the starch in individual guard-cells.

We have devised such a method, using as our measure the *area* of the starch-grains. Strips of epidermis were mounted in Heath's[1] reagent (which stains the starch without affecting the aperture), and stomata selected at random were photographed on 35-mm. film (Kodak 'Microfile'). The resulting negatives were projected from a Leica enlarger to give an overall magnification of 2,500 linear dimensions; the outlines of the starch-grains and the aperture were traced in pencil, and the areas measured with a planimeter. The starch grains do not lie accurately



o–o–, Stomata from enclosed area: ● – ● –, stomata from unenclosed area

in one plane, and almost invariably some are slightly out of focus; this difficulty could be eliminated by direct projection of the original slide on to a screen for tracing, re-focusing as necessary. However, the necessary equipment has not been available, and the photographic method has therefore been adopted for preliminary experiments. The use of a photometric method for measuring the areas has been fully considered, but, for reasons which cannot be detailed here, rejected.

We have carried out two simple experiments which demonstrate the striking results that the technique affords. In the first, part of an illuminated *Pelargonium* leaf was enclosed between two glass plates; it is already known[4,5,6] that the resulting drop in carbon dioxide concentration causes wide stomatal opening between the plates. A strip of lower epidermis was taken from both enclosed and unenclosed parts of the leaf by Lloyd's[7] method, the strips were transferred to Heath's reagent, and the starch and aperture measured in twenty stomata from each strip. The results are shown in the accompanying scatter-diagram. It will be immediately clear that, within any one treatment, there is no sign whatever of the high negative correlation that classical theory might lead us to expect; but that enclosure has significantly increased aperture and reduced starch. It might still be argued that starch–sugar balance, though not responsible for variations in aperture between individual stomata under substantially constant conditions, yet controls major changes in aperture. However, Heath[2], referring particularly to the work of Iljin[8], has pointed out that enclosure also increases the humidity of the air so enclosed, and has implied that there may be two effects—reduction of carbon dioxide acting upon aperture, increase of humidity acting upon starch—which have been confounded. Despite the intractability of *Pelargonium* in February, we have attempted to investigate this by enclosing part of a leaf between plates incorporating a drying-agent (calcium chloride). Visual inspection discloses immediately that such enclosure does not cause any appreciable diminution in starch-content; in fact, our computations suggest that there has been a statistically significant increase in both aperture and starch. However, since we are as yet ignorant of the extent to which these quantities vary over the surface of any one leaf, we place no reliance on this result; but it at least seems clear that the technique here outlined will enable us to undertake a fully quantitative investigation of this and related phenomena.

We are indebted to Dr. O. V. S. Heath for the loan of apparatus and to Mr. G. L. Robbins of Kodak, Ltd., for technical advice. A full discussion of the technique and a detailed account of the preliminary experiments will be published elsewhere in due course.

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High Light Intensities for Experiments in Crop Physiology

Attention has recently been devoted in this Department to the development of a growth cabinet in which the environment can be controlled, eventually for use in pasture research in New Zealand. For this purpose the critical requirement is high light intensity with the quality of daylight, over an area large enough for adequate replication of the experimental plants. It is the experience of plant physiologists that it is difficult to obtain such lighting without the complications caused by excessive radiation. The following note may therefore be of interest.

The growth cabinet used can be run at any temperature from 40° F. to 75° F. ± 2° F., by circulating air past a heater and a thermostatically controlled cooler. There is no water screen between the lights and the plants. The evenly illuminated area is 5 sq. ft.; it receives light from twelve 150-watt tungsten filament reflector spotlamps and twelve experimental 30-watt, 3-ft., blue fluorescent tubes. These lamps provide a continuous spectrum which, compared with sunlight, is slightly weaker in green and stronger in blue and red. The present maximum intensity at the level of the plants, 18 in. from the lamps, is equivalent to sunlight at 2,000 foot-candles. Below each tungsten bulb is a disk of Chance's '*O.N.*20' heat-absorbing glass 6 in. in diameter. Even when more than two kilowatts are being put into the lamp circuit, it has been necessary to switch on an 80-watt heater to maintain cabinet temperature at 70° F.

Experiments are being carried out on strains of *Lolium* under this light intensity. The evidence to date does not suggest that 2,000 foot-candles is the maximum to which *Lolium* will respond, and arrangements are being made to increase the light intensity still further.

In the design of the lighting arrangements particular thanks are due to Dr. J. N. Aldington, of Siemens, Ltd.

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Occurrences in Normal Human Sera of 'Incomplete' Forms of 'Cold' Auto-Antibodies

THE existence of 'incomplete' forms of antibodies active against human erythrocytes and detectable by means of the Coombs test[1] is now widely recognized. *Rh* antibodies are commonly present in this form, and so are some at least of the recently recognized rarer immune antibodies[2], such as anti-*Kell* and anti-*S*. The fact that the iso-antibodies anti-*A* and anti-*B* may similarly exist in incomplete forms is also being increasingly realized[3].

The possibility that 'cold' auto-antibodies might also exist in incomplete forms seems, however, scarcely to have been considered. Although Levine and Wigod[4] mentioned that 'cold' agglutinins might be a cause of confusion in carrying out the Coombs 'developing' test, they gave no details of the phenomenon. The purpose of the present note is to record that incomplete 'cold' antibodies active against corpuscles of all groups do, in fact, exist, and that they may be found in most, if not in all, sera from apparently healthy persons, as may 'cold' panhæmagglutinins at low titres.

The presence of these normally occurring incomplete 'cold' antibodies can often be demonstrated if defibrinated blood is chilled at 2–5° C. for 1–2 hr., and the corpuscles then exposed to the action of anti-globulin rabbit serum, after repeatedly washing them in saline warmed to 37° C. In these circumstances, although the 'cold' hæmagglutinins are rapidly eluted into the warm saline, the incomplete antibodies appear to remain adsorbed on to the corpuscles. A stronger reaction can be obtained if a weak (0·5–5 per cent) suspension of corpuscles is made in their own serum and dealt with as described above. Sometimes with weak suspensions a positive Coombs test will be obtained in this way, even if the sensitization is carried out at room temperature.

There is evidence that the presence of fresh serum is necessary for the adsorption of the antibody, for corpuscles suspended in serum previously heated to 56° C. for 5–30 min. fail to give a positive reaction after chilling. The addition of a small amount of absorbed fresh serum to heat-inactivated serum restores in part, however, its power of sensitizing corpuscles. Heparin (0·5 mgm. per ml.), sodium citrate (6 mgm. per ml.) or Wintrobe's oxalate mixture (2 mgm. per ml.) added to serum also inhibit sensitization to a greater or less extent, depending upon the titre of the antibodies and the potency of the anti-globulin rabbit serum. Another pointer to qualitative differences between incomplete 'cold' antibodies and incomplete anti-*Rh* is that anti-globulin rabbit sera are not necessarily equally effective in revealing sensitization by the two kinds of antibodies. Some sera, for example, although highly potent in revealing sensitization by anti-*D*, give weaker reactions with corpuscles sensitized by incomplete 'cold' antibodies, and *vice versa*.

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Heteropycnosis in Human Chromosomes

INVESTIGATORS of human chromosomes noticed many years ago the presence of two chromatic masses or chromocentres in resting nuclei. On the other hand, Schultz[1] was able to analyse in male human material the structure of a couple of elements pairing at pachytene during spermatogenesis, each spatially connected with a nucleolus, and, therefore, called nucleolus organisers.

The question arises whether there is a relationship between nucleolus-organising chromosomes seen in the spermatocytes, and the two chromocentres appearing in resting nuclei of different tissues[2]. Suitable material is provided by the epithelial cells flaking off from the vaginal mucosa. Collecting the vaginal fluid at the vaginal ostium, the cells are numerous and in a living condition, some of them showing mitotic stages. The usual squash technique with Acetocarmine staining is sufficient to give good preparations. Nearly four hundred nuclei have been analysed, from eight women.

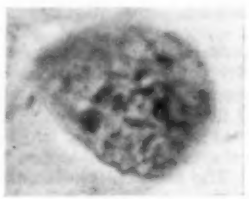


Fig. 1

Fig. 1*a*

Fig. 1. Nucleus with two nucleoli. The nucleolus-organising chromosomes are very thin

Fig. 1*a*. Drawing of the nucleus in Fig. 1, showing nucleoli and nucleolar chromosomes only

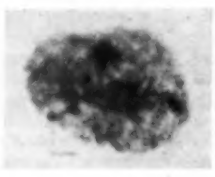


Fig. 2

Fig. 2*a*

Fig. 2. Nucleus with one chromocentre, and one nucleolar chromosome clearly stained

Fig. 2*a*. Drawing of the nucleus in Fig. 2

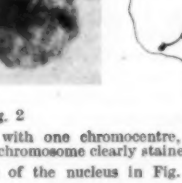


Fig. 3. Nucleus with two chromocentres. Nucleoli not visible. (Magnification nearly 1,000 ×)

Such cells have nuclei showing all stages, from the nucleolus-organising chromosomes with the same structure as that described by Schultz to two chromocentres: these two extreme cases are connected with a continuous chain of intermediate stages, where one of the chromosomes is contracted (chromocentre) and the other appears in thread-like form (see Figs. 2 and 2*a*). This provides evidence that the nucleolus-organisers are present also in the

female, having the same structure as is described by Schultz, and, therefore, must be considered as autosomes. Secondly, it seems that each nucleolus-organiser is capable of forming one chromocentre.

Summarizing, it can be said that in the forty-eight chromosomes of man, there are two which are characterized by a varying degree of heteropycnosis, at the lowest degree of which they are often scarcely distinguishable from the remainder of the chromatin.

The determination of the origin and number of the chromocentres in normal nuclei is of interest in connexion with the problem of detecting proliferating malignant cells, where the chromocentres are abnormally numerous[3].

C. Barigozzi
P. Feletig

Istituto di Genetica dell'Università di Milano,
Clinica Ostetrica e Ginecologica
dell'Università di Torino.
Jan. 21.

[1] Schultz, J., *J. Heredity*, **40**, 31 (1949).
[2] Barigozzi and Cusmano (unpublished data).
[3] Koller, P. C., *Nature*, **151**, 244 (1943).

Anomalous Results of Moth-Proofing Tests

In the course of testing the efficiency of moth-proofing agents, anomalous results were obtained with two well-known compounds which had been applied in conjunction with a neutral levelling acid dye (Xylene Fast Blue). Further work on the problem is unlikely in this laboratory so these results are presented here.

The two moth-proofing agents were: (*A*) a substituted urea derivative, and (*B*) a sulphonic acid derivative of triphenyl methane. Shrink-controlled knitted woollens were moth-proofed at a woollen mill by the following method. The dye-bath was adjusted to an initial *p*H of about 8 with ammonia. The ingredients were added and the bath heated to 100° C. in 15 min. This temperature was maintained for a further 15 min., when the *p*H was adjusted to 5 with acetic acid. The woollens were then removed and rinsed twice.

Moth-proofing efficiency was determined by loss of weight of fabric tests[1] with the larvæ of two species of clothes moth (*Tinæa pellionella* L. and *Tineola bisselliella* Hum.). Further determinations of efficiency were made after two, four and six washings of the domestic type using a commercial soap powder. Chemical analysis showed a loss of the moth-proofing agent with washing (Fig. 1); but despite this there was a steady increase in moth-proofing efficiency after each washing (Fig. 2). This increase in efficiency was shown in separate series of tests with both species of moths for both (*A*) and (*B*).

Further tests carried out with agent (*A*) applied at 60° C. in an acid bath without dye on the same shrink-controlled fabric gave a usual curve of efficiency with both species of test insects, the efficiency decreasing with decrease of moth-proofing agent after washing (Fig. 3).

Where the moth-proofing agents were applied in the dye-bath under the first set of conditions, there was an apparent inhibition of moth-proofing efficiency which was progressively removed by washing. Thus, though chemical analysis might show a concentration of agent which was theoretically adequate for protection, in practice the efficiency of the agent might be too low to prevent damage. We would be interested to learn whether other workers have encountered this same anomaly and if any explanation is forthcoming.

K. P. Lamb

Plant Diseases Division,
P.B. Auckland,
New Zealand.
Feb. 1.

[1] Lamb, K. P., *N.Z. J. Sci. Tech.* (In the press).

Reciprocal Translocations in *Pisum*

Some years ago I published an analysis of structurally changed types of *Pisum sativum* based on cytological observations[1]. One of these, structural type four which had arisen in the variety Extra Rapid, was reported as having chromosomes 3 and 5 interchanged, according to my notation. Recently, Lamm[2] and Nilsson[3] have challenged this statement, and on the basis of their genetical evidence claim that the *K* line (chromosomes 1 and 2 interchanged) and the Extra Rapid translocation have the chromosome carrying the *GP* factor, chromosome 2 on my notation, in common, and predict that the cross Extra Rapid × *K* should have an association of six chromosomes.

My records showed that this cross had two associations of four chromosomes, indicating that two separate chromosomes are involved in the two interchanges. This I have confirmed by a re-examination

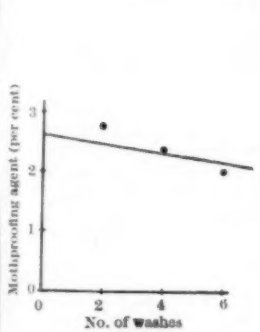


Fig. 1

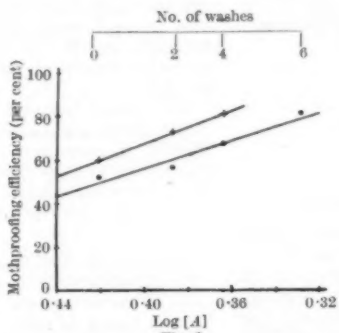


Fig. 2

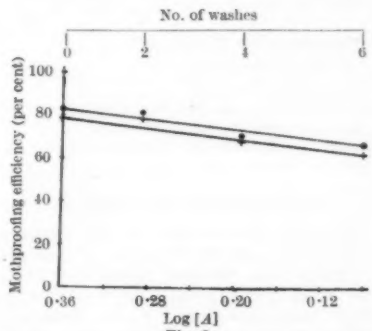
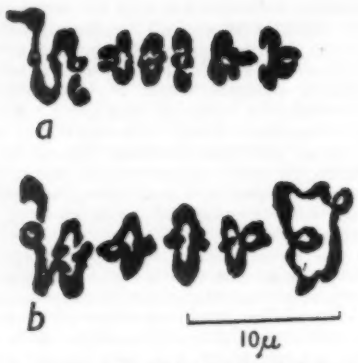


Fig. 3

Fig. 1 Removal of '*A*' by washing. Fig. 2. Efficiency of '*A*' applied with dye at 100° C.: ●–●–, *Tinæa pellionella* L.; +–+–, *Tineola bisselliella* Hum. Fig. 3. Efficiency of '*A*' applied without dye at 60° C.: ●–●–, *Tinæa pellionella* L.; +–+–, *Tineola bisselliella* Hum.



Meiotic chromosomes in Extra Rapid translocation crossed (*a*) standard, (*b*) *K* line

of the slides. Fig. (*a*) shows the meiotic chromosome complement in the hybrid between the Extra Rapid translocation and the standard line, and Fig. (*b*) shows that of the *K* line crossed the Extra Rapid translocation. Two associations of four and three bivalents are clearly seen.

The accompanying table gives further results of crosses involving the Extra Rapid translocation. These indicate that chromosomes 3 and 5 are involved, as in my original communication.

Results of crossing Extra Rapid translocation

Line	Chromosomes interchanged	Configurations
Structural Type 1	—	Association of four
" " 2	1 and 2	Two associations of four
" " 3	1 and 3	An association of six
" " 6	1 and 4	Two associations of four
" " 5	4 and 5	An association of six

From correspondence with Dr. Lamm, I learn that the two translocations in the Extra Rapid variety arose independently. Therefore, it would seem that two different translocations are involved.

The genetical evidence of Lamm[2] indicates that *GP* on chromosome 2 is involved, and that of Nilsson[3] suggests linkage with *B*ʳ *St* on chromosome 3, which would indicate that the Swedish Extra Rapid translocation involves chromosomes 2 and 3. The two Extra Rapid translocations, if crossed, should give an association of six since they have chromosome 3 in common.

EVA SANSOME

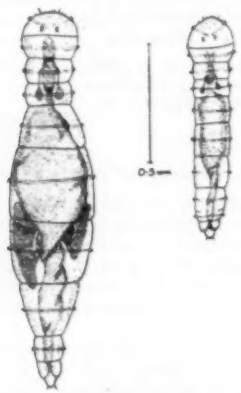
University College,
Ibadan, Nigeria.
May 17.

[1] Sansome, E., *Nature*, **139**, 113 (1937).
[2] Lamm, R., *Hereditas*, **35**, 203 (1949).
[3] Nilsson, E., *Hereditas*, **36**, 75 (1950).

An Archiannelid from South Africa

SEVERAL specimens of an Archiannelid were recently found on portions of the thallus of the prostrate alga, *Codium Stephensiæ* Dickinson, which had been kept in an aquarium for some months. They were also found to be abundant among the débris on the bottom of the tank. The *Codium* had been collected at Kommetjie on the Cape Peninsula some twenty-two miles south of Cape Town.

The little worms are members of the genus *Dinophilus* Schmidt. Members of this genus fall into two groups: the species of one group are usually coloured, opaque and sexually monomorphic; the species of the other are usually colourless, transparent and sexually dimorphic. The South African specimens fall into the second group. The adult females are about 1–1·5 mm. long, and their appearance is very similar to the descriptions of *Dinophilus gyrociliatus* Schmidt, as given by Shearer[1] and Fauvel[2], and they differ only in the presence of an extra segment (if the portion between constrictions constitutes a segment), and in the absence of any definite circum-anal ciliary band. The males are rudimentary and never leave the egg cocoon, where as soon as they become free from the egg membrane they were seen to copulate with the young females.



Adult (left) and juvenile (right) female of *Dinophilus gyrociliatus* from South Africa

Considering that Fauvel[2] unites with *D. gyrociliatus* several species formerly separated by slight differences, the points of difference shown by these South African specimens do not seem to be sufficient to justify the making of a new species to include them, in spite of the fact that they have been found so far from the known range of *D. gyrociliatus*. Since these differences were found to be constant in some hundreds of specimens examined, they may be sufficient to constitute a new variety, and this will be proposed in a paper giving a full description of the specimens, to be published later.

So far as I can ascertain from the literature at my disposal, this is the first record of an Archiannelid not only from South Africa but also from the southern hemisphere.

My thanks are due to Prof. J. H. Day, of Cape Town, for confirmation of my identification, and to Miss P. L. Smuts, of the Department of Botany, University of Cape Town, for identifying the species of *Codium* on which the animals must have been introduced into the aquarium.

WM. MACNAE

Department of Zoology,
University College,
Grahamstown,
South Africa.

[1] Shearer, C., *Quart. J. Micr. Sci.*, **57** (1912).
[2] Fauvel, P., "Faune de France: Polychaetes sédentaires" (Paris, 1927).

FORTHCOMING EVENTS

Monday, July 3—Friday, July 7

INSTITUTE OF PETROLEUM (at the Royal Technical College, Glasgow).—Conference on "Oil Shale and Cannel Coal".

Tuesday, July 4—Friday, July 7

ASSOCIATION OF APPLIED BIOLOGISTS (at Edinburgh).—Summer Meeting.

Thursday, July 6

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Lieut.-General Sir William MacArthur: "The Story of Smallpox in the British Isles".

Friday, July 7

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Dr. Lauriston S. Taylor (Washington, U.S.A.): "The Measurement of X- and Gamma-Radiation over a Wide Energy Range" (Twenty-ninth Silvanus Thompson Memorial Lecture).

Friday, July 7—Saturday, July 8

PHYSICAL SOCIETY (in the Lecture Theatre, George Holt Physics Laboratories, The University, Brownlow Hill, Liverpool).—Summer Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College, Hull (July 8).

LECTURER IN BIOLOGY (preferably with qualifications in Zoology and Physiology)—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (July 8).

LECTURER IN CHEMISTRY—The Principal, Acton Technical College, High Street, Acton, London, W.3 (July 8).

LECTURER IN CHEMISTRY, a LECTURER IN METALLURGY, a LECTURER IN MATHEMATICS, and a RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS for investigations at high frequencies—The Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham 1 (July 8).

LECTURER IN TELECOMMUNICATIONS in the Department of Physics and Telecommunications, and a LECTURER IN PHYSICS—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (July 8).

RESEARCH FELLOW IN INDUSTRIAL METALLURGY, to work in the field of melting and casting of metals—The Secretary, The University, Birmingham 3 (July 8).

SENIOR ASSISTANT with experience in Food and Drug Analysis, with special reference to spectrography and spectrophotometry, and a TECHNICAL ASSISTANT with particular interest in the field of spectrophotometry and spectrography, in the Laboratory of the Public Analyst—The Secretary and Registrar, The University, Bristol (July 8).

STATISTICIAN (with University degree with first- or second-class honours, or a degree of equivalent standard, and wide experience of statistical work) to the Secretary of State for Scotland's Department—The Establishment Officer, S.H.D., Room 364, St. Andrew's House, Edinburgh 1 (July 8).

TEACHER IN BIOLOGY (with good degree in Botany with Zoology as subsidiary)—The Principal, Norwood Technical College, Knight's Hill, London, S.E.27 (July 8).

VETERINARY PATHOLOGIST (Grade II), and VETERINARY INSPECTORS (Grade III), in the Veterinary Department of Cyrenaica—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.184/50A (July 10).

PRINCIPAL SCIENTIFIC OFFICER IN THE SHIP DIVISION OF THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON (with first- or second-class honours degree, preferably in naval architecture, or high professional attainments in that subject, and experience of research work on hydrodynamic or aerodynamic problems)—The Secretary, Civil Service Commission, Scientific Branch, 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3135 (July 13).

ELECTRONIC ENGINEERS or PHYSICISTS (unestablished, Experimental Officer grade) in the Royal Aircraft Establishment (Instrumentation Dept.), Farnborough, Hants—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.170/50A (July 14).

PHYSICISTS or ELECTRONIC ENGINEERS (Experimental Officer grade, unestablished) at a Ministry of Supply Research and Development Establishment near London, for work in (a) electronic instrumentation associated with high-speed photographic technique and strain gauges, (b) general experimental work involving small mechanism and instruments, (c) experience of practical spectroscopy and some familiarity with electronic techniques, (d) radio and electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.158/50 (July 14).

ASSISTANT IN THE DEPARTMENT OF ANIMAL GENETICS—The Secretary, The University, Edinburgh (July 15).

DEMONSTRATOR IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Singleton Park, Swansea (July 15).

LECTURER IN CHEMISTRY (main subject should be physical chemistry, preferably with experience in colloid chemistry), and a LECTURER IN BIOLOGY (with qualifications mainly on the zoological side, with ecological experience)—The Registrar, University College of North Staffordshire, Keele, Stoke-on-Trent (July 15).

MECHANICAL and AERONAUTICAL ENGINEERS (Senior Experimental Officer grade, unestablished) at the Royal Aircraft Establishment (Structures Department), Farnborough, Hants, in the following fields of work: (1) fatigue of aircraft structures, (2) strain gauge installations on aircraft calling for electronic experience with ability to adapt instruments for use in this connexion on the ground and in flight, (3) aircraft accident investigations, (4) static aero-elastic, flutter and vibration problems of aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.300/50A and Post No. (July 15).

RESEARCH FELLOW IN THE DEPARTMENT OF MINING, to take charge of a team carrying out research on the chemical constitution of coal—The Secretary, The University, Birmingham 3 (July 15).

SENIOR EXPERIMENTAL OFFICER (Ref. F.355/50A), with qualifications in engineering or chemical engineering, preferably to Degree standard, with knowledge of handling chemicals and ability to control industrial staff, and an EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (Ref. F.356/50A), with at least H.S.C. or equivalent qualification, with experience in engineering and/or chemistry and ability to work well in a team of scientific and industrial workers, at a Ministry of Supply Research and Development Establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (July 15).

SENIOR SCIENTIFIC OFFICER (unestablished) (with a good honours degree in civil engineering or equivalent qualification, and have studied the effect of static loads either in roads, airfields or foundations), at a Ministry of Supply Engineering Establishment in Hants—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting E.276/50A (July 15).

TECHNICAL OFFICER (woman, with degree in chemistry and administrative or industrial experience) in the Technical and Scientific Register—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.380/50A (July 15).

PRINCIPAL SCIENTIFIC OFFICERS IN THE MECHANICAL ENGINEERING RESEARCH ORGANISATION OF THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: (a) Engineer for research into the properties of engineering materials at high temperatures, (b) an Engineer with experience of the application of research in industry to lead research into generic problems of mechanical engineering in the Division studying lubrication, wear, and the mechanical engineering aspects of corrosion, etc., and (c) a Physical Chemist to lead a research group studying the fundamental factors underlying the process of wear and its modification by the presence of lubricants—The Secretary, Civil Service Commission, Scientific Branch, 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3141LA (July 18).

LECTURER IN NATURAL HISTORY (with special qualifications in vertebrate zoology or comparative physiology)—The Secretary, The University, Aberdeen (July 20).

ASSISTANT LECTURER IN CIVIL ENGINEERING—The Registrar, Queen Mary College, Mile End Road, London, E.1 (July 22).

RESEARCH OFFICER (with University degree with honours, with physics and/or mathematics as a major subject or equivalent qualifications, and experience in some branch of theoretical physics applicable to low-temperature research) in the Division of Physics, National Standards Laboratory, Sydney—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 2900 (July 22).

SCIENTIFIC OFFICERS (with first- or second-class honours degree in physics and good general electronic knowledge and experience), at Ministry of Supply Research and Development Establishments near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.172/50A (July 24).

SENIOR EXAMINER (male, with honours degree in physics with chemistry as a subsidiary subject, or an honours degree in chemistry with physics as a subsidiary subject) in the Ministry of Fuel and Power—The Secretary, Civil Service Commission, Scientific Branch, 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3126 (July 28).

BIOPHYSICIST to the Clinical Research Unit of Alfred Hospital, Melbourne—The Agent-General for Victoria, Australia House, Strand, London, W.C.2 (Melbourne, July 31).

DE BEERS CHAIR OF ENGLISH LANGUAGE in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

EMBRYOLOGIST or IMMUNOLOGIST in the Department of Zoology, to undertake research on fertility in mammals—The Secretary and Registrar, University College of North Wales, Bangor (July 31).

PROPAGATOR (with National Diploma in Horticulture or an equivalent qualification, and a sound practical knowledge of the propagation of fruit plants)—The Secretary, Research Station, Long Ashton, Bristol (July 31).

RESEARCH ASSISTANT IN THE DEPARTMENT OF CHEMISTRY, University College, Dundee, to undertake work on the thermodynamics of solutions—The Registrar, The University, St. Andrews (July 31).

AGRICULTURAL SUPERINTENDENTS for extension work, H.M. Colonial Service, Sierra Leone—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 32055/19/50 (August 15).

SENIOR LECTURER IN APPLIED AND INDUSTRIAL CHEMISTRY, and a LECTURER IN ORGANIC CHEMISTRY, in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.2 (August 15).

PROFESSOR OF FIELD HUSBANDRY, and a PROFESSOR OF SHEEP HUSBANDRY, at Massey Agricultural College, Palmerston North, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 21).

ANALYST, preferably experienced in the analysis of non-ferrous metals and alloys—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

ASSISTANT EXPERIMENTAL OFFICER (with a degree in science or equivalent qualifications) to assist with the Drosophila research programme—The Executive Assistant, Animal Breeding and Genetics Research Organisation, Kings Buildings, West Mains Road, Edinburgh 9.

ASSISTANT LECTURER IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—The Secretary, Royal Technical College, Glasgow.

ASSISTANT LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING, and a DEMONSTRATOR IN CHEMISTRY—The Registrar, The University, Nottingham.

BIOCHEMIST (with degree or equivalent in chemistry) in the Department of Pathology—The Secretary, Welsh National School of Medicine, 34 Newport Road, Cardiff.

BIOCHEMIST (with honours degree in chemistry or equivalent, and extensive experience in hospital biochemistry)—The Secretary, Romford Group Hospital Management Committee, Oldchurch Hospital, Romford, Essex.

GRADUATE LECTURER IN BIOLOGY in the Chemistry Department—The Principal, North Staffordshire Technical College, Stoke-on-Trent.

GRADUATES (with first- or second-class honours in physics or chemical engineering) to work on the application of physics in fuel technology, including temperature and fluid flow measurement, properties of suspensions of particles and the general application of physical techniques—The Secretary, British Coal Utilisation Research Association, Randalls Road, Leatherhead, Surrey.

HEAD OF THE DEPARTMENT OF HYGIENE AND PUBLIC HEALTH—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, University College, Exeter.

LECTURER IN BIOLOGY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3.

LECTURER IN BOTANY (with particular interest in plant physiology) for classes up to B.Sc. (Special) Degree standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

LECTURER IN PHYSICS (with honours degree in physics) in the Department of Natural Philosophy—The Secretary, Royal Technical College, Glasgow.

MALARIA FIELD OFFICER by the East Africa High Commission—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.25969/3A.

PHYSICIST (honours graduate preferably with research experience) primarily for work on physical properties of powders and suspensions and methods of processing such materials, a CHEMIST (graduate) primarily for work on surface chemistry of fine powders and analytical work, and an EXPERIMENTAL ASSISTANT (of Intermediate B.Sc. standard)—The Director of Research, British Whiting Federation, 245 Ampthill Road, Bedford.

RESEARCH FELLOWSHIP for research into problems connected with heating and ventilating—The Secretary, Institution of Heating and Ventilating Engineers, 75 Eaton Place, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

B.I.O.S. Surveys Report No. 22: The Paint Industry in Germany during the Period 1939–1945. By Neil R. Fisk and H. W. Brown. Pp. 153+4 plates. (London: H.M. Stationery Office, 1950.) 3s. net. [274

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines for the Year 1948. Northern Division. Report by T. A. Jones. Pp. 39. (London: H.M. Stationery Office, 1950.) 1s. net. [274

Association of British Insecticide Manufacturers. Directory, 1950. Pp. 124+xxvi. (London: Association of British Insecticide Manufacturers, 1950.) Free. [15

British Non-Ferrous Metals Research Association. Thirtieth Annual Report, April 1950. Pp. 64+2 plates. (London: British Non-Ferrous Metals Research Association, 1950.) [15

Institution of Electrical Engineers. Regulations for the Electrical Equipment of Buildings. Twelfth edition. Pp. vi+202. (London: Institution of Electrical Engineers, 1950.) Paper, 3s. 6d.; cloth, 5s.

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 18: Concrete Kerbs, Causes and Prevention of Failures. By J. A. Loe. Pp. iv+18+2 plates. (London: H.M. Stationery Office, 1950.) 9d. net. [25

British Standards 628–32 and 650–56: 1950, Vegetable Oils. Pp. 50. 6s. net. British Standard 684: 1950, Methods of Analysis of Oils and Fats. Pp. 92. 7s. 6d. net. British Standard 1640: 1950, Steel Butt-Welding Fittings for the Petroleum Industry. Pp. 18. 7s. 6d. net. (London: British Standards Institution, 1950.) [25

Report of the Departmental Committee on Children and the Cinema. (Cmd. 7945.) Pp. v+109. (London: H.M. Stationery Office, 1950.) [95

Iodine and Plant Life: Annotated Bibliography 1813–1949, with Review of the Literature. Pp. xi+114. (London: Chilean Iodine Educational Bureau, 1950.) [95

Magic, Craftsmanship and Science. The Frazer Lecture delivered at Liverpool, 10th November 1949. By V. Gordon Childe. Pp. 19. (Liverpool: University Press of Liverpool, 1950.) 1s. [95

Report of the Rugby School Natural History Society for the Year 1949. (83rd Issue.) Pp. 48. (Rugby: George Over, Ltd., 1950.) [95

Fair Isle Bird Observatory. First Annual Report, 1949. Pp. 32+13 plates. (Fair Isle, by Lerwick: Fair Isle Bird Observatory, 1950.) 2s. 6d. [95

The Determination of Carotene in Dried Grass Meal: being an Account of the Evolution of a Simple Method and a Collaborative Test of its Reliability. By Duodecim Viri. Pp. 16. (Navenby: British Crop Driers, Ltd., 1950.) [95

General Notes on the Preparation of Scientific Papers. (Published for the Royal Society.) Pp. v+26. (London: Cambridge University Press, 1950.) 2s. 6d. net. [95

International Committee for Bird Preservation, British Section. Annual Report for 1949. Pp. 38+4 plates. (London: International Committee for Bird Preservation, c/o British Museum (Natural History), 1950.) 2s. [95

Bibliography of Publications and Reprints of the Safety in Mines Research and Testing Branch. Pp. 34. (London: Ministry of Fuel and Power, 1950.) [95

Other Countries

O.N.E.R.A. Publication No. 38: La haute atmosphère. Par R. A. Boutet. Pp. vii+121. Publication No. 40: Eléments d'acoustique aéronautique. Par Dr. P. Lienard, M. Kobrynski et P. Autzenberger. Pp. 84. (Paris: Office National d'Études et de Recherches Aéronautiques, 1950.) [244

Berichte der Naturforschenden Gesellschaft zu Freiburg i. Br. Herausgegeben von Prof. Dr. M. Pfannenstiel. Band 39, 1943–49. Pp. 320. (Freiburg i. Br.: Naturforschenden Gesellschaft, 1949.) [244

Zur Kenntnis der Kontakt-Insektizide, II. Von Dr. Randolph Riemschneider. (Die Pharmazie, Beiheft 9, Ergänzungsband 1.) Pp. 647–800. (Berlin: Dr. Werner Saenger, 1950.) [244

East African Meteorological Department. Report for the Year 1949. Pp. 22. (Nairobi: East African Meteorological Department, 1950.) [274

Proceedings of the United States National Museum. Vol. 100, No. 3268: A Contribution to the Ornithology of Northeastern Venezuela. By Herbert Friedmann and Foster D. Smith, Jr. Pp. 411–538+plates 10–12. (Washington, D.C.: Government Printing Office, 1950.) [274

Contributions from the United States National Herbarium. Vol. 29, Part 9: New Grasses from Mexico, Central America, and Surinam. By Jason R. Swallen. Pp. v+395–428. (Washington, D.C.: Government Printing Office, 1950.) 15 cents. [274

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